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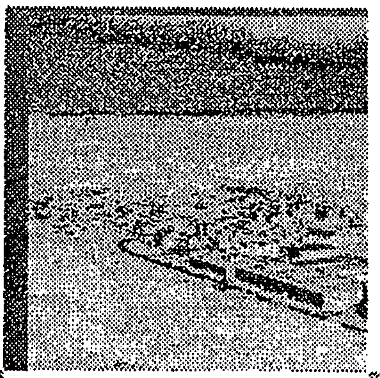

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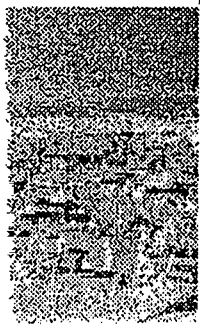

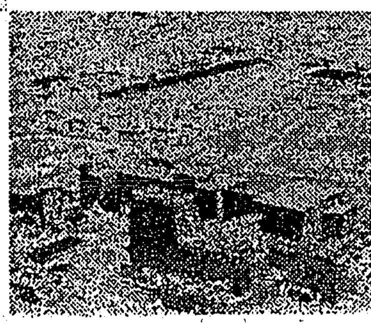

Prepared by
Site and Facilities Planning Department
Martin Marietta Energy Systems, Inc.
for the
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This province is characterized by numerous elongated ridges and intervening valleys. The configuration of the area's terrain was a primary factor in the selection of Oak Ridge as the site for the top-secret Manhattan Project because it enhanced security. The Valley of East Tennessee is located between the Cumberland Plateau, which is the southern portion of the structural province known as the Appalachian Plateaus, and the Blue Ridge province, a portion of the Appalachian Mountain chain. The Great Smoky Mountains National Park, located within the Blue Ridge mountains, contains some of East Tennessee's most prominent geographical features and is 113 km (70 miles) to the southeast of Oak Ridge. Figure 1.1 shows the geographic location of the ORR.

Most of the ORR is located within the corporate limits of the city of Oak Ridge in East Tennessee. The reservation is located approximately 3.2 km (2 miles) southwest of the population center of Oak Ridge and is bordered on the southwest by the Clinch River and Melton Hill Lake impoundment (Fig. 1.2). The ORR consists of 14,030 ha (34,667 acres) of federally owned lands within Anderson and Roane counties, with Knox and Loudon counties to the south. The three primary plant complexes located on the site are the Oak Ridge K-25 Site, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Y-12 Plant.

The city of Oak Ridge was built to house the people who erected and initially operated the three facilities for the Manhattan Project. Knoxville, the largest city in East Tennessee, is located approximately 48 km (30 miles) east of Oak Ridge. Although most employees reside within 40 km (25 miles) of the ORR, employment opportunities attract many employees who commute 80 to 120 km (50 to 75 miles) daily from their homes in surrounding counties.

1.1.2 History

For over 50 years, government missions and operations have been the primary factor in the development of Oak Ridge. Since the early 1940s, before Oak Ridge became an incorporated city, missions on the ORR were vital to the nation's strategic energy and defense plans. As programs on the ORR evolved, its management and resources have received ever greater attention.

Little more than 50 years ago, the area now occupied by the city of Oak Ridge was undeveloped farmland. Electricity was introduced to the area in 1935 by the Tennessee Valley Authority (TVA). The quiet countryside underwent a drastic change in 1942 when, after a nationwide search, a site consisting of 23,877 ha (59,000 acres) in East Tennessee was chosen to house a community brought together for one purpose: large-scale production of fissionable material for the world's first nuclear weapon. The land was purchased by the Manhattan Engineering District, a special unit of the U.S. Army Corps of Engineers, at a cost of $2.6 million. This top-secret government project was known as the Manhattan Project.

Clinton Laboratory

On February 1, 1943, work began in Bear Creek Valley on the first uranium enrichment facility; it was designated Y-12. About 10 km (6 miles) away, in Bethel Valley, work was started on the X-10 nuclear research facility. Now known as the Oak Ridge National Laboratory, X-10 was the site of the world's second nuclear reactor. In September 1943, construction began on the gaseous diffusion enrichment facility, the principal building being designated K-25. By mid-1945, "the city behind the fence," so called because of the extensive use of guards, roadblocks, and fences on the site, had a population of 75,000 and employment at the three facilities reached a peak of 82,000 (ORO 1972).

On August 6 and 9, 1945, the world learned the nature of the U.S. government's secret, multimillion dollar mission in Oak Ridge when an atomic bomb was dropped on Hiroshima and then another on Nagasaki, Japan. The end of World War II came shortly thereafter in September 1945, and the population of Oak Ridge began to decline as people began returning to their pre-war occupations.

In January 1947, the Atomic Energy Commission (AEC) assumed control of the operations at Oak Ridge as part of its mandate to oversee the nation's nuclear energy effort. The Union Carbide Nuclear Division was contracted to manage the land and facilities for the government, implementing the strategic long-range plans of the AEC to sustain Oak Ridge as a center of nuclear research and production. Activity at the three plant complexes flourished: ORNL expanded into a major research and development (R&D) facility, Y-12 became a vital production plant for weapons components, and K-25 became a national leader in enriching uranium through the gaseous diffusion process. The fences around the city were opened to the public in 1949. Government land was first leased to the public in 1953, with the first parcels being excessed and sold in 1956. When the community of Oak Ridge incorporated in 1959, much of the land comprising the city had already been transferred to private or municipal ownership (ORO 1972). The 14,030 ha (34,667 acres) that now make up the ORR is the only portion of the land bought to support the Manhattan Project that remains under federal government ownership.

Management efforts on the ORR during the 1940s focused primarily on providing land for the expansion and development of the three plant complexes and their mission programs; however, ORR land began being used for waste storage in the mid-1940s, and by the 1950s environmental research was being conducted. Additional land uses established on the ORR to support the three plant missions included administration, technical services, education and medical research, support services, controlled buffer areas, waste management, recreation, cemeteries, visitors centers, and natural areas.

In 1975 the Energy Research and Development Administration (ERDA) succeeded AEC as the operator of the reservation. The *ORR Land-Use Plan* (ERDA Report ORO-748) was published that same year to establish a basis for long-range land-use planning to accommodate government mission requirements in Oak Ridge. In addition to technological requirements, this land-use plan incorporated in-depth ecological concepts recognizing multiple uses of land as a viable option. The protection and maintenance of unique biological areas, rare and endangered species, and human and environmental health and safety was given a high

I think ORO existed before 1977

priority. In 1980 DOE updated and revised this plan [DOE/ORO-748 (Rev.1)] to reflect evolving programmatic needs (Oakes et al., 1984).

With the formation of DOE in 1977, oversight of the Oak Ridge facilities became the responsibility of DOE Oak Ridge Operations (ORO). As the goals of the government agencies changed, the emphasis on research and production activities at the Oak Ridge facilities also changed. With the expansion of technology came an increase in environmental and ecological research, and the Oak Ridge facilities played a key role in applying ecological concepts to environmental problems. Activities on the ORR eventually began to tax the existing reservation resources, thus creating a need for responsible management of these resources.

In 1980, a management plan for the Oak Ridge National Environmental Research Park (Research Park) was prepared by the staff of ORNL and ORO. The plan was accepted by the Manager of ORO and the Assistant Secretary for Environment, DOE, in January 1981 (Preston 1984). A Research Park, as defined by DOE, is an outdoor laboratory in which research may be conducted to achieve environmental goals defined by three pieces of legislation: the National Environmental Policy Act of 1969 (NEPA), the Energy Reorganization Act, and the Nonnuclear Energy Research and Development Act. Numerous scientists have utilized the Research Park for their research in support of our National Energy Policy since its dedication in 1980 (Preston 1984).

In August 1982, a Reservation Resource Management Committee, now referred to as the Resource Management Organization (RMO), was established to develop a plan for managing the resources of the ORR. This committee, composed of representatives of numerous resource categories, has provided the mechanism for reviewing proposed activities on the reservation. The RMO's role in the administration of the planning process is discussed further in Sect. 5.

In 1984, Martin Marietta Energy Systems, Inc., (Energy Systems) replaced Union Carbide Nuclear Division as the prime contractor to DOE for the management of the three plant complexes on the ORR. The long-term strategic goal within Energy Systems is to be recognized nationwide for leadership in protecting ~~our people~~ employees, the public, and the environment, while conducting outstanding research and development, maintaining first-rate production operations, and remedying past environmental practices (MMES 1992).

As a continuation of land-use planning on the ORR, the *Oak Ridge Reservation Site Development and Facilities Utilization Plan* (DOE/OR-885) was published in June 1989. The primary purpose of this planning document was to provide a management tool to help ensure the orderly growth and development of the ORR and its facilities.

IN standby SINCE 1985

Since the end of the Cold War, the missions for the three plant complexes on the ORR have changed. The gaseous diffusion plant at the current K-25 Site was shut down in 1987 because the need to produce enriched uranium in large amounts decreased significantly. However, the K-25 Site is now involved in environmental restoration and waste management activities. The weapons-component production at the Y-12 Plant ~~will be~~ has replaced by weapons disassembly, and ORNL conducts a diversified research and development program on a ~~variety of energy technologies~~. A principal focus at all three facilities is to transfer technologies and skills developed for defense programs to the private sector.

this mission hasn't changed

In the 1990s, the ORR, a large area capable of housing multiple programs and land uses, remains an invaluable national resource. While primarily supporting the programmatic requirements of the three plant complexes, it also provides a unique laboratory for demonstrating the environmental compatibility of energy technology developments (e.g., environmental restoration and environmental monitoring). As the missions of DOE are modified to support the technological needs of the country, the reservation will continue to be an excellent location for new initiatives.

Table 1.24

Soil groups and associated series

Soil group	Soil series
	Residuum
Geologic formation	
Rome Group	Lehew, Armuchee-Muskingum, Calvin
Conasauga Group	Sequoia, Armuchee, Apison, Montevallo, Collegedale
Knox Group	Fullerton, Bodine, Clarkesville, Dunmore
Chickamauga Group	Gladeville, Talbott, Collegedale, Colbert, Upshur-Variant
	Colluvium
Source of colluvium	
Rome and Conasauga groups	Jefferson, Shouns, Leadvale, Shelocta
Knox Group	Minvale, Tasso, Roane, Emory, Greendale, Tarklin
	Alluvium
Age of soil material	
Holocene/Modern	Hamblen, Pope-Philo, Newark, Melvin
Pleistocene	Allen, Dewey, Claiborne Holston, Waynesboro, Etowah, Nolichucky

Source: Lietzke et al. 1986

These soil groups are generally derived from geologic rock groups of similar title. Rome soils are usually on steep slopes and have a very high erosion potential if vegetation is removed and the surface is left bare. Mass earth or mud flows can occur on steep slopes of Rome soil (Hancock et al. 1992). Knox soils are potentially good for construction sites, forestry, and preserving wildlife. Chickamauga soils are shallow but have fair potential for forest production. Alluvial soils are in the rich bottomlands and are generally excellent for forestry, wildlife, and agriculture. Soil groups found on the ORR are discussed in Sect. 2.6.3.

1.7.4 Hydrology

The surface hydrology in the Valley of East Tennessee is characterized by a trellis pattern in which the Tennessee River is the primary receiver of many secondary rivers and their tributaries, e.g., the Powell, the Clinch, the Holston, the French Broad, the Little Tennessee, the Hiwassee, the Tellico, and the Ocoee (see Fig. 1.24). The Tennessee River is formed by the juncture of the Holston and French Broad rivers at Knoxville.

The ORR is located in the Clinch River watershed, which comprises about 11% of the Tennessee River watershed. The Clinch River originates in southwestern Virginia and flows 563 km (350 miles) to join the Tennessee River at Kingston, Tennessee (Kornegay et al. 1992). It supplies essentially all of the water to the ORR, Oak Ridge, and other cities along its course. Since it is also the primary receiver of drainage from the ORR, discharges into the river must be monitored to ensure that water passing downstream satisfies all applicable state and federal water quality standards. A discussion of site-specific hydrology is found in Sect. 2.6.5.

Five dams operated by TVA control the flow and level of the Clinch River. Norris Dam, the first TVA dam, was built in 1936 and is approximately 50 km (31 miles) upstream from the ORR. It was built to provide electric power and prevent severe flooding along the Clinch River. Melton Hill Dam, completed in 1963, controls the flow of the river near the reservation, with its primary purpose being power generation rather than flood control (Boyle et al. 1982). Fort Loudon and Tellico dams, on the Tennessee and Little Tennessee rivers upstream of the Tennessee's confluence with the Clinch River, control water flow into Watts Bar Lake, which is formed by Watts Bar Dam (Kornegay et al. 1992). Watts Bar Dam, on the Tennessee River, affects flow on the lower reaches of the Clinch (Rothschild et al. 1984).

Heavy precipitation below Norris Dam causes localized flooding, primarily in Oak Ridge. Historically, this flooding has been triggered by severe seasonal rainstorms, which can occur during the winter and spring (December to April) or during the summer thunderstorm season.

SW ↑

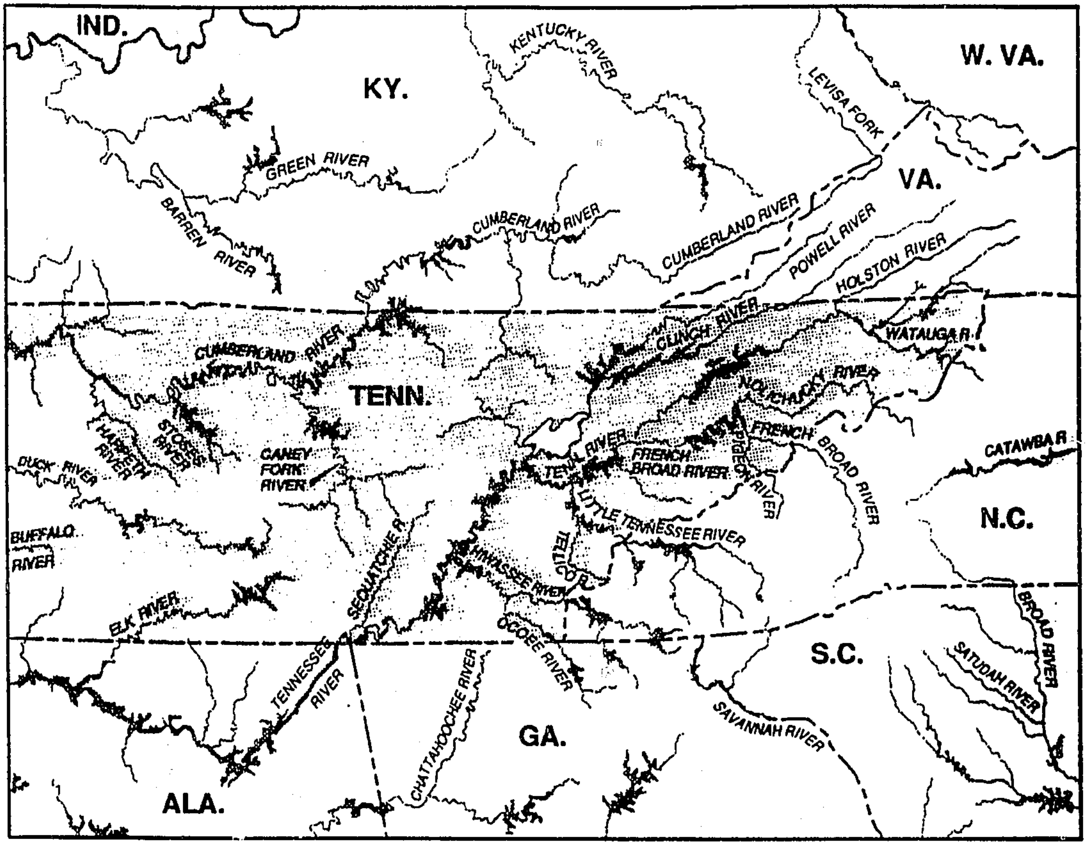
GW ↓

Groundwater provides water to many rural residents, industries, and public water systems. Twenty-one percent of all water used in the state is groundwater; it serves an important agricultural use for irrigation and livestock, and over 50% of Tennessee's population relies on groundwater for drinking water supplies (Kornegay et al. 1992). Within the five-county planning area, approximately 11% of all households use wells as a principal water supply for domestic or agricultural uses (Kornegay et al. 1992). Considering this extensive use of groundwater, protection is of extreme importance. Groundwater occurrence, monitoring, and protection efforts specific to the ORR are discussed in Sect. 2.6.4.

Typically, there is a close relationship between surface water and groundwater drainage patterns. Groundwater in the Oak Ridge area flows generally from locations at higher elevations to lower elevations, discharging into streams and the Clinch River, thus sustaining baseflow to these systems. A stream will typically gain and lose flow as subsurface water seeps into and out of the stream channel.

In the Valley of East Tennessee, groundwater occurs in bedrock, in the regolith (loose rocky material resting on bedrock), and in a few alluvial aquifers along the largest rivers (Kornegay et al. 1992). Aquifers are underground storage areas for water. They form when the passage of water into the earth is stopped by the presence of an aquitard, material which resists the flow of water. Aquifers in the Valley of East Tennessee (see Fig. 1.25) are

ORNL-DWG 93M-5217



LEGEND

- Oak Ridge Reservation
- Rivers and Lakes
- State Line

TRUE NORTH

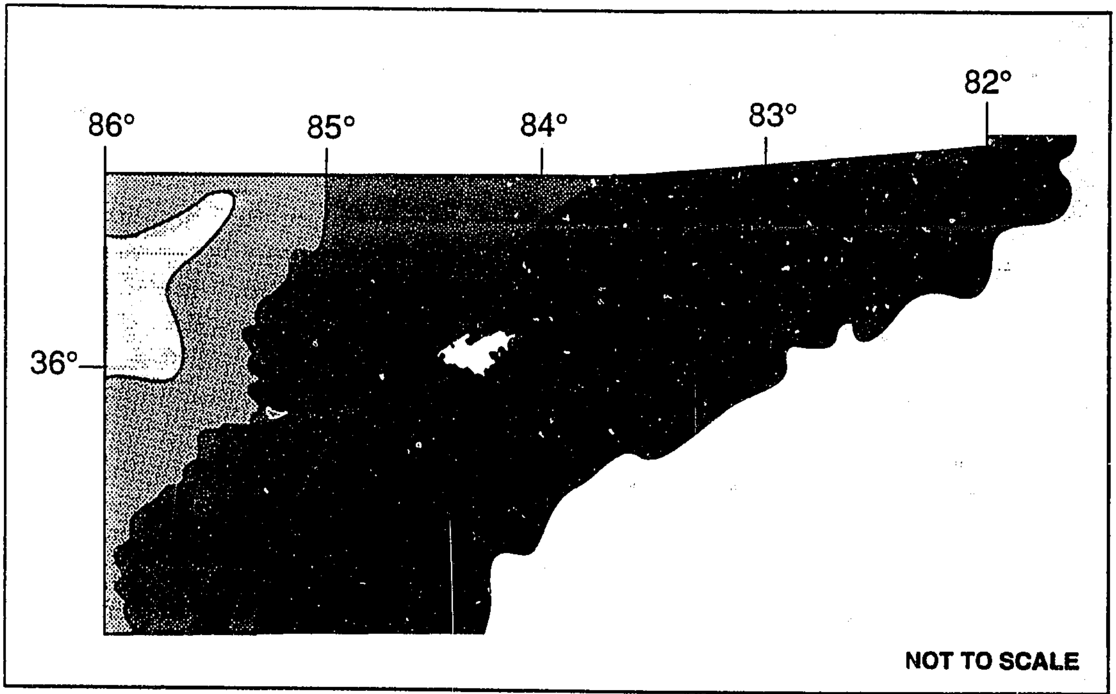
MILES 0 25 50 100

0 50 100 150 KILOMETERS

Fig. 1.24

Primary rivers in East Tennessee.

ORNL-DWG 87M-10038R2



NOTE: Degree measurements reference the Tennessee state plane grid.

LEGEND

- Ordovician Carbonate Aquifer
- Mississippian Carbonate Aquifer
- Pennsylvanian Sandstone Aquifer
- Cambrian-Ordovician Carbonate Aquifer
- Crystalline Rock Aquifer
- Oak Ridge Reservation

SOURCE: Adapted from Kornegay et al. 1991

Fig. 1.25

Principle aquifers in East Tennessee.

carbonate aquifers, which are made from limestone and dolomite. Carbonate aquifers are among the most prolific water supplies in the U.S. (Wilson 1982).

1.7.5 Special Considerations

Wetlands have received considerable attention in the past several years as a natural resource in need of protection. Wetlands are areas that are periodically saturated with or covered by water, have hydric soils, and are dominated by hydrophytic (water-loving) plants. They are important to a region's ecology because they provide a habitat for resident and migratory wildlife, absorb flood waters, and improve groundwater quality and quantity. Thus, federal and state governments have enacted laws strictly regulating the use of and impacts on wetlands. This regulation, discussed further in Sect. 1.9, creates an important planning consideration. Wetlands characteristic of the planning region include emergent communities in shallow embayments, emergent and aquatic communities in ponds, forested wetlands on low ground along major creeks, and wet meadows and marshes associated with streams and seeps (Cunningham and Pounds 1991). Wetlands on the ORR are discussed in Sect. 2.6.6.

1.8 METEOROLOGY

The Oak Ridge area's location within ridge and valley terrain and its position east of the Cumberland Plateau influences the local climate. In addition, like many other areas having continental climates, the Oak Ridge area is influenced by air masses of both Arctic and tropical origin. This can result in a wide range of weather conditions. However, the Oak Ridge area's mid-latitude location (36°N) usually ensures some moderation of Arctic and tropical air masses before they reach the local area (Birdwell 1993).

1.8.1 Sun Angles

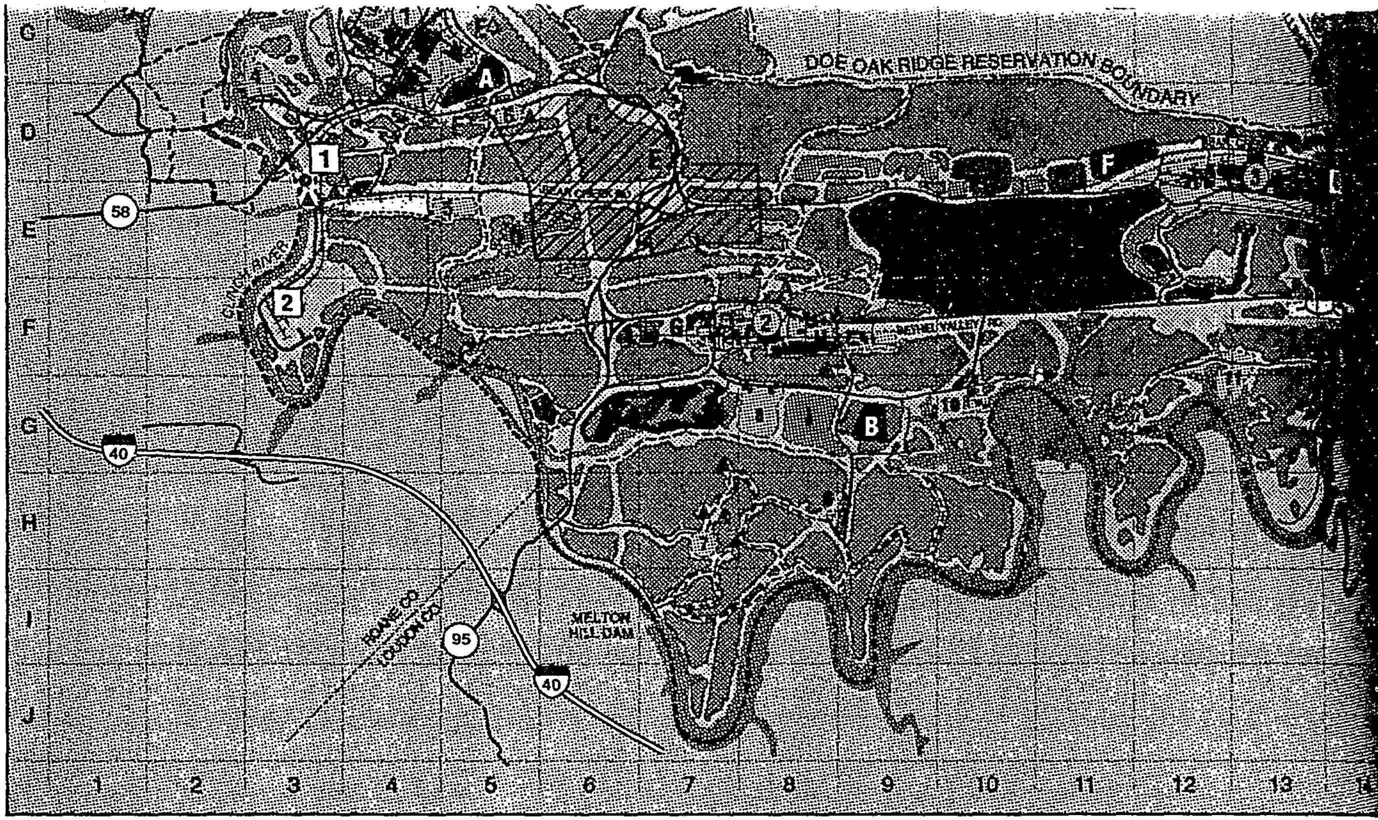
The amount and intensity of sunlight reaching Oak Ridge vary greatly throughout the year. Figure 1.26 shows the vertical and horizontal paths of the sun during the seasons. The heavy cloud cover associated with long-duration, low-pressure fronts accounts for up to one-third of the winter sky conditions. An additional third of the winter weather is derived from arctic fronts that also bring snow and rain, but they quickly yield to clear skies and cold temperatures.

The intensity and duration of sunlight peak in the summer when a succession of cloudy days are rare. However, solar intensity is diminished somewhat by the moisture content of the air. In the summer, weather fronts centered in the Gulf of Mexico send moisture-laden southerly winds through the region, saturating the air until a rainstorm breaks and the cycle begins again.

1.8.2 Temperatures

The area has a relatively mild climate with warm to hot, humid summers and cool, wet winters. The relatively high humidity experienced year round is generally attributed to the influence of the Gulf of Mexico and the Atlantic Ocean (Birdwell 1993).

The National Climatic Data Center (NCDC) recalculates the area's "normal" temperatures each decade using climate data from a recent 30-year period. The current base period for NCDC climatic normals is 1961–1990. More recent climate normals (1963–1992



NOTE: Grid shown is Oak Ridge administrative grid.

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5. Central Training Facility
6. Transportation Safeguards (SR 58)
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2 Substation 700: Clinch River Industrial Park Substation Improvements

3 West Wastewater Treatment Plant Improvements

4 Reconfiguration of the Y-12 Elza Substation

Road Improvements and Additions

1 State Route 62 increased to 7 lanes from South Tulane to Boeing Interchange and major improvements made to its existing intersection with Scarboro Road and Lafayette Drive and Boeing Road Interchange

2 Major geometric improvements to intersection at Bethel Valley Road and Scarboro Road

3 Scarboro Road increased to 4 lanes and a more efficient intersection added at Bear Creek Road and Union Valley Road

4 Intersection of Union Valley Road and Second Street with Scarboro Road improved

5 State Route 62 increased to 4 lanes from Solway Bridge to Boeing Interchange

6 Interchange provided at State Route 62 and Bethel Valley Road

2.1 CURRENT MISSIONS AND PROGRAMS

Current operations on the ORR are guided by the missions of the three primary plant complexes. The lack of a specifically defined mission treating the ORR as a single site is the most important issue facing the ORR. Currently it is difficult to determine what mission should drive the planning and development of the ORR.

The three principal missions pursued at the plant level, supported by associated programs and subcontracting agencies, are

- Energy research and development (R&D) at ORNL;
- Reclamation and storage of nuclear material, manufacturing of defense hardware, and national security, Technology Transfer, and Work for Others programs at Y-12; and
- Environmental restoration and waste management (ERWM) at the K-25 Site.

The ORR is managed by Martin Marietta Energy Systems, Inc., for the Department of Energy Oak Ridge Operations Office (DOE-ORO). One of the most diversified field offices in the DOE complex, DOE-ORO is responsible for a broad range of production, research, education, and training activities associated with energy development, demonstration, and applications. It is also responsible for a major part of the design and construction of new and improved production and research facilities on the ORR, and it provides administrative assistance to the Office of Scientific and Technical Information (OSTI).

Other programs, prime contractors, and management and operating (M&O) contractors within the DOE-ORO complex with missions directly related to activities on the ORR are Oak Ridge Associated Universities (ORAU), Oak Ridge Institute for Science and Education (ORISE), OSTI, Johnson Controls, and MK-Ferguson (MK-F).

2.1.1 ORNL

ORNL is one of DOE's largest multiprogram energy laboratories and research facilities. The *ORNL Institutional Plan, FY 1993–98,* states that the primary mission of ORNL is to perform leading edge research and development in support of the nonweapons roles of DOE. Important elements of this mission are to

- perform basic and applied research of importance to the nation,
- provide the scientific and technical community with unique national user facilities,

Forty-two facilities at the Y-12 site have been identified as being contaminated, with the primary contaminant being radionuclides. Approximately 194,841 m^2 (2.1 million ft^2) or 37% of the total square footage of building space at Y-12 is documented as contaminated (Coleman 1993).

2.5.2 Utilities

The major utilities serving the ORR are electrical power, raw and treated water, sanitary sewerage, natural gas, and telecommunications. In addition, coal is transported to the plants by truck and is used to produce steam at ORNL and is a backup fuel at the Y-12 steam plant. There are 110.8 km (68.85 miles) of electrical transmission lines, 42.9 km (26.64 miles) of water mains, 30.9 km (19.21 miles) of gas mains, and 58.5 km (36.38 miles) of telecommunications lines on the ORR. Figure 2.8 shows the utility systems on the ORR.

Effective management of these utility systems requires that an appropriate land area and adequate rights-of-way be dedicated for their physical location, maintenance, and access. In some cases, utility rights-of-way may also support the management of other facilities and resources by providing ground cover for wildlife, areas for research, and access for forestry operations and security patrols.

Ages of the utility systems vary. Most were constructed in the 1940s during the initial development of the ORR to support the large production facilities. Improvements to the systems have been conducted on an as-needed basis in order to maintain system reliability; however, the age and size of the equipment causes decreased reliability and increased operating costs.

Electrical systems

DOE has delegated management responsibility for the Oak Ridge area substation and transmission system to the K-25 Power Operations Department of the Site Services Division. This responsibility includes contract administration, operations, and maintenance.

The ORR electrical system is supplied power from four major power sources in the TVA system: Kingston Steam Plant, Bull Run Steam Plant, Wolf Creek Hydroelectric Plant, and Fort Loudon Hydroelectric Plant. The K-731 substation at the K-25 Site, plus the K-741 substation at Y-12 and the K-751 substation at ORNL, make up the DOE Oak Ridge Area power system, with each substation being an integral part of the TVA system. The substations are tied together on-site by five DOE 161-kV transmission lines. Power is supplied to ORR substations by 6 TVA electrical lines at a nominal voltage of 161 kV that is reduced to 13.8 kV for distribution (see Fig. 2.8). The ORR electrical system components are listed in Table 2.11. The system is monitored 24 hours a day by the Supervisory Control and Data Acquisition (SCADA) system.

Table 2.11

ORR electrical system components

System components	Estimated quantity			
	K-25 Site	ORNL	Y-12	Total
Main power transformers, 161/13.8 kV, rated 40 to 120 MVA	6	3	16	25
Secondary power and distribution transformers, 13.8 kV and below, rated from 5 to 15,000 kVA	210	310	570	1090
Circuit breakers, 480 V to 161 kV	800	690	2000	3490
Motor control centers, 480 V	220	125	500	845
Distribution panelboards, 120/205/240 V	400	1400	2500	4300
Miles of overhead 161-kV lines	16	0	6	22
Miles of overhead 13.8-kV lines	10	19	30	59
Miles of underground 13.8-kV cables (in ducts)	60	1	10	71
Miles of 2.4-kV overhead and underground lines/cables	15	15	6	36
Estimate of system replacement cost in millions of dollars	100–150	50–100	250–300	350–500

Source: Dunlap 1993

Assuming full utilization, maximum power availability is 660 MW. The maximum contracted power available to the ORR is 135 MVAP; however, this amount could be expanded upon request with a contract change. Total power capacity available to the ORR is unknown because TVA would need to review the potential demand of a new facility to identify how to meet that demand. Because of the nature of its supply system, it is likely that all demands could be met by TVA although the specifics of how are dependent on the demand. The average daily operating usage on the ORR is 115 MVAP (68 MVAP at Y-12, 19 MVAP at the K-25 Site, and 28 MVAP at ORNL). The total system load capacity is approximately 60% of the capacity of the Bull Run Steam Plant. The electrical load for the ORR is summarized in Table 2.12.

When K-25 was enriching uranium, the ORR had a capacity of 2180 MVAP. Since the shutdown of K-25's enrichment operations in the mid-1980s, that potential has not been utilized. Extraneous electrical equipment has been decommissioned and sold; however, the transmission lines that connect the ORR to the TVA system are still in place. The potential of the existing ORR electrical system is 810 MVAP, with only moderate modifications to the distribution systems at each plant site.

Table 2.12

Summary of electrical load for the ORR

Plant	Capacity	Previous 10-year peak (since 1/80)	Peak load (8/89)	Percent utilization
K-25 Site	240 MW	1000 MW	19 MW	8
ORNL	115 MW	31 MW	27 MW	23
Y-12	545 MW	91 MW	70 MW	13

Source: Dunlap 1993

All major transmission lines on the ORR have been constructed according to TVA standards and specifications and are either 161 or 500 kV. The classification of transmission lines on the ORR is presented in Table 2.13. Most of the original rights-of-way on the ORR were routed through wooded areas. Rights-of-way have been cleared of trees that present a danger to the transmission lines. Generally, cleared rights-of-way for transmission lines are 30.5 m (100 ft) wide for 161-kV lines and 45.8 m (150 ft) for 500-kV lines. Trees are designated as dangerous if in falling they would reach within 1.5 m (5 ft) of a 161-kV line or within 3 m (10 ft) of a 500-kV line.

All transmission-line corridors along ridges are either grassed or covered with low-growing vegetation for erosion control. Corridors across open fields are used in basically the same way as if the transmission lines were not there (usually for crops or pasture). In other areas on the ORR, corridors are used for equipment storage, parking areas, and other uses not requiring permanent structures. Some rights-of-way are either research sites or habitats for rare plants.

The K-25 Site power system is supplied by the K-731 switchyard, which has an internally allocated capacity of 23 MW. The current annual demand is approximately 19 MW. Power is received from one DOE and three TVA 161-kV lines, is reduced to 14 kV, and is distributed to approximately 110 distribution transformers through 64 km (40 miles) of underground cable and overhead power and lighting circuits.

Power is transmitted throughout the Y-12 Plant by three 161-kV overhead radial feeders (designated as Y-12 No. 1 line, Y-12 No. 2 line, and Y-12 No. 3 line) and one 161-kV interconnecting overhead feeder by means of 150-MVA automatic regulators located at the Elza 1 substation. The eastern section of the No. 2 line supplies a specific ORNL load in Y-12 from the Elza 1 switchyard. The lines are three-phase, single-circuit lines rated at 220-MVA capacity. Some sections of the lines are supported from suspension insulators on self-supporting steel towers; however, most sections are supported from suspension insulators on wooden pole H-frame structures. The Elza switchyard is currently being redesigned and reconstructed to eliminate the transfer bus. The new station will consist of a new control house, all SF_6 breakers, and 2 buses (north and south) (Dunlap 1993).

Table 2.13

Classification of transmission lines on the Oak Ridge Reservation

Description	Voltage (kV)	Length km	Length miles	Tower construction materials
TVA lines crossing the reservation but not terminating at DOE substations				
Bull Run/Roane	500	25.3	15.7	Steel
Wilson/Roane	500	2.1	1.3	Steel
Watts Bar/Roane	500	11.1	6.9	Steel
Harriman/Roane	161	4.2	2.6	Wood
Norris/Oak Ridge	161	3.5	2.2	Wood
Bull Run/Oak Ridge	161	6.1	3.8	Steel
Bull Run/North Knox. No. 1	161	3.9	2.4	Steel
Bull Run/Lonsdale No. 2	161	3.9	2.4	Steel
Bull Run/Alcoa	161	3.9	2.4	Steel
Kingston/Bull Run	161	31.9	19.8	Steel
Kingston/Ft. Loudon	161	8.9	5.5	Steel/Wood
Roane 3/Kingston	161	4.1	2.5	Steel
Roane 5/Kingston	161	4.2	2.6	Steel
Roane 6/Kingston	161	4.2	2.6	Steel
TVA lines terminating at DOE substations				
Bull Run/Elza	161	12.6	7.8	Steel/Wood
Wolf Creek/Elza	161	5.0	3.1	Steel
Fort Loudon/Elza	161	14.5	9.0	Wood
Kingston 1/K-27	161	2.6	1.6	Steel
Kingston 2/K-27	161	2.6	1.6	Steel
Ft. Loudon/K-27	161	5.5	9.6	Steel
DOE substation tie lines				
X-10/Elza	161	9.8	6.1	Wood
X-10/K-27	161	13.2	8.2	Steel/Wood
Elza/Y-12 No. 1	161	2.9	1.8	Steel/Wood
Elza/Y-12 No. 2	161	2.9	1.8	Steel/Wood
Elza/Y-12 No. 3	161	2.9	1.8	Steel/Wood

Electrical power to the ORNL electrical distribution system is supplied from the ORNL primary substation located north of the plant. The substation receives power from the DOE 161-kV system and transforms it to the 13.8 kV level. Distribution within the plant is by way of eight 13.8-kV feeders. Five secondary 2.4-kV substations, a 2.4-kV distribution system, distribution switchgear and numerous facility transformers further distribute power within the plant. Operating practice at ORNL is not to exceed 50% of design MVA to maintain switching flexibility in the event of an outage.

The system includes 51.5 km (32 miles) of overhead pole distribution lines, 6.4 km (4 miles) of underground cable, 20 medium voltage distribution switchgear assemblies, and over 200 facility transformers. The system has a total capacity of 80 MVA. The present electrical load averages 19 MW.

Raw and treated water

Both the Clinch River and the Melton Hill Reservoir supply water to the ORR. Because they are a part of the TVA flood control system, they are capable of maintaining a constant volume of water well in excess of the demands of the three facilities. Total potable water capacity available to the ORR is 40.2 Mgd, obtained through the K-25 and Y-12 treatment plants. Current ORR usage is 18.3 Mgd, providing a reserve capacity of 21.9 Mgd.

Raw (untreated) water for the DOE water treatment plant is supplied by a pumping station on Melton Hill Reservoir (Clinch River mile 41.7) near Y-12. It is pumped through a 42-in. pipe and a 36-in. pipe for a distance of about 915 m (3000 ft). At the 915-m point, the lines change to two 24-in. pipelines that carry the raw water an additional 1.8 km (1.1 miles) to a 5678-kL (1.5-million-gal) raw-water storage tank and booster pumping station east of Y-12. Raw water is then pumped about 1220 m (4000 ft) from the raw-water storage tank to the DOE treatment facility, on Pine Ridge, just north of Y-12. This treatment facility can process an estimated 105,980 kL/d (28 Mgd). Capacity can be increased to 32 Mgd without modifications. The sanitary (treated) water is stored in two reservoirs with a combined capacity of 26,498 kL (7 million gal). From the reservoirs, water is supplied by gravity flow to the Y-12 Plant, ORNL, the Scarboro Facility, and the city of Oak Ridge.

Treated water is routed from the filtration plant to Y-12 facilities by three lines: one 24-in. main and two 16-in. mains. The average treated water usage is approximately 7 Mgd for the Y-12 Plant, 5 Mgd for ORNL, and 4.5 Mgd for the city of Oak Ridge.

South of Y-12, along the South Patrol Road on Chestnut Ridge, are three additional emergency storage tanks. Each tank has a capacity of 7571 kL (2 million gal) and is connected to the Y-12 sanitary water distribution system. Release valves for these emergency storage tanks can be activated by the shift superintendent.

The Scarboro Facility, located at the intersection of Bethel Valley Road and Scarboro Road, receives its sanitary water from an extension of the Y-12 plant distribution system. A 12-in. water line is routed from the east end of Y-12 to the Scarboro Facility. This 12-in. line also ties into the water lines serving the Valley Industrial Park, located east of Y-12 along

Union Valley Road. Redundancy is provided by an 8-in. line, which is valved out unless needed.

Water for ORNL is carried by a 24-in. main from the DOE treatment facility reservoirs. This 24-in. main is routed along Bear Creek Road near the Anderson-Roane County line and then in a southwesterly direction to Chestnut Ridge and an 11,356-kL (3-million-gal) reservoir. Another 3-million-gal reservoir (two 1.5-million-gal tanks) located on Haw Ridge is supplied by a 20-in. line connected to the 24-in. main. From these two systems, which are interconnected by check and regulating valves, water flows by gravity into ORNL's distribution system. Outlying facilities such as the Tower Shielding Facility, the Health Physics Research Reactor, and the Consolidated Fuel Reprocessing Facility are also served by ORNL's distribution system.

The sanitary water system at K-25 consists of a raw-water pumping station (K-1513) on the Clinch River at mile 14.5, a filtration and treatment plant ~2.4 km (1.5 miles) south of the plant, two water storage tanks (K-1529 and K-1530) on Pine Ridge, and a distribution system that exceeds 30.6 km (19 miles) of pipe. This system provides potable water not only to the K-25 Site, but also to the powerhouse, the Transportation Safeguards Facility, and the city's Clinch River Industrial Park. The water treatment facility provides a capacity of more than 4.1 Mgd, and is fed by two storage tanks (total capacity of 4 million gallons), on Water Tank Hill near west Bear Creek Road. Current usage is approximately 2 Mgd, leaving a reserve capacity of 2 Mgd. This excess is an asset for future new projects on the ORR. The distribution system consists of 10- and 12-in. cast iron mains that operate with normal gravity feed pressure of 75 psi. The pipes are in good condition despite their age, although several valves have been or are being replaced. The sanitary water system is over 45 years old; however, it is very reliable. Capital improvements have been and are currently being made to enhance operability and maintainability.

Oak Ridge receives most of its water supply from the DOE treatment facility near Y-12. (The one exception is water supplied by K-25 to the industrial park on Bear Creek Road.) Three interconnected main lines (12-, 16-, and 30-in.) leave the treatment facility to supply the city's distribution system. The city of Oak Ridge buys water from DOE/K-25 for the Clinch River Industrial Park, which is south of Bear Creek Road and near the water treatment plant. The city, in turn, provides distribution and sells water back to DOE for the Central Training Facility, adjacent to the industrial park.

Sanitary Sewerage

The ORR does not have a centralized sewerage system for all facilities. The K-25 Site and ORNL have their own sewerage systems, while Y-12 shares sewage lines with the city of Oak Ridge. The sanitary sewage effluent from the Y-12 Plant flows to the Oak Ridge West End Treatment Plant. Approximately 16 km (10 miles) of underground mains, ranging in size from 4 to 18 in., handle the sewage effluent at Y-12. DOE maintains the sewage lines extending from Y-12 to the east end of the security road (Bear Creek Road). The city of Oak Ridge maintains the sewage lines from the end of the security road to the treatment plant on west Oak Ridge Turnpike. Minor contamination problems from Y-12 effluent experienced in the past have been resolved. See Sect. 1.3.5 for more information.

The sanitary sewerage system for the K-25 Site consists of an extended aeration-type treatment plant (K-1203), ten lift stations, approximately 1341 m (4400 ft) of force main, and approximately 15,545 m (51,000 ft) of gravity mains. The treatment plant is considered reliable and is permitted by the National Pollution Discharge Eliminations System (NPDES). There are no anticipated capacity problems, except during periods of heavy rain when infiltration of rainwater places a heavy load on the system.

The sewerage system serving ORNL consists of three parts: a gravity and forced-main collection system serving the main (Bethel Valley) area of the plant; a collection, pump and haul system serving facilities in the Melton Valley area; and septic tank/drainfield systems serving the other outlying facilities. In the main plant area, piping systems carry wastewater into the Laboratory's own 300,000 gpd extended aeration-type sewage treatment plant. Currently the ORNL sewage treatment plant discharges approximately 240,000 gpd of treated effluent into White Oak Creek in full compliance with all permit requirements.

Sanitary sewage from ORNL facilities located in the Melton Valley area is collected through either facility-specific or area-specific piping grids. These grids flow into collection tanks located near the facilities where the wastewater is collected. A 6000-gallon tanker truck is used to haul collected sewage to the sewage treatment plant. Sanitary sewage from other ORNL facilities, such as the Tower Shielding Facility and the Consolidated Fuel Reprocessing Facility, located in the outlying areas of the reservation is collected and treated through facility-specific septic tank/drain field systems. ORNL currently has 10 facilities served by this means of disposal.

A Sanitary Sewer Upgrade line-item project has been funded and is currently in design. This $16,000,000 project addresses rainfall infiltration, and pipe liner installation. A new sewer line is being sized to accommodate future growth in the east area of the plant. Another new line will be constructed to collect sewage in the Melton Valley area.

Because of their remoteness and low volume of use, outlying facilities such as the powerhouse area, the Central Training Facility, the Transportation Safeguards Facility, and the water treatment plant utilize septic tanks with drain fields. The powerhouse area has a package treatment plant (K-710-A), with a rated capacity of 20,000 gpd, which is not in use because of the low volume of sewage.

Natural gas

DOE has delegated management responsibility for natural gas supply matters to the K-25 Site Services Division, Power Operations Department. These responsibilities include contract administration, usage monitoring, management of interruptible supplies during curtailment, invoice verification, usage and cost estimates, regulatory oversight, and assistance to Y-12 and ORNL in a variety of gas matters. The following information on natural gas was provided by J.T. Bradsher, Engineering Division, K-25 Power and Utilities Department.

Areas with traffic flow problems were identified on the east end of the reservation on Scarboro Road, State Route 62, Bear Creek Road, and Bethel Valley Road. The LOS in these areas ranges from D to F, which is unacceptable under most operating circumstances.

The following intersections on the reservation are also considered to have traffic flow problems: Scarboro Road and Bear Creek Road, Scarboro Road at the Scarboro "Y", Scarboro Road at Union Valley Road, and Bear Creek Road at various portal entrances. These situations are well documented in *Bear Creek Road Traffic Analysis* prepared by Theta Technologies, Inc., in 1989 and *Scarboro Road Traffic Analysis* prepared by EC Design and Theta Technologies, Inc., in 1987.

Bridges and culverts

The ORR has numerous small rivers and streams that must be traversed by bridges and culverts of varying sizes and strengths. There are over 100 bridges and culverts along major roads on the ORR and about 100 more on minor access and maintenance roads.

Responsibility for inspection and maintenance of bridges and culverts is scattered among several different agencies. Generally, each of the three plants is responsible for maintaining any structures within its own borders. Bridges and culverts located within the reservation but outside individual plant areas are maintained by the agency that owns or maintains the road on which the structure is located. Among these are TDOT, the Forestry Management Division, and the on-site construction and maintenance contractors (Johnson Controls and MK-F).

Inspections and surveys were performed in 1990 by Science Applications International Corporation (SAIC) under Subcontract 17B-99060V, Task K38, to inventory all bridges and culverts on the ORR, with major or heavily used roads being given priority. During these inspections, the type of structure (bridge or culvert) was identified, physical characteristics were briefly described, and the location verified. Guidelines set by TDOT were followed to determine the type of structure. In general, these guidelines state that any structure greater than 6.1 m (20 feet) in length is a bridge, and any structure less than 6.1 m (20 feet) in length is a culvert, with the length of a structure measured along the center line of the roadway from abutment to abutment.

Parking

Parking facilities on the reservation are generally limited to the three main plant sites and individual building groups such as the Central Training Facility, IT Corporation, and EG&G. Refer to the individual plant TSIs for in-depth information concerning site-specific parking.

The K-25 Site has approximately 18.6 ha (46 acres) dedicated to parking. Most of this space is located outside the main portals of the plant. Although the overall number of parking spaces throughout the site exceeds current demand, the existing distribution of

Natural gas contract. East Tennessee Natural Gas Company (ETNG) is the sole supplier of natural gas to the ORR. ETNG acquires the gas supply, then transports the gas from the supply areas through upstream pipelines and then through its own pipeline system for ultimate delivery to the ORR. Currently there is no other single pipeline in the area capable of meeting all of ORR's gas requirements. DOE is served directly by ETNG. There is no local distribution, or utility company, between ETNG and DOE.

By its sales contract with DOE, the maximum daily quantity of gas that ETNG is obligated to deliver to the ORR is 22.45 billion Btu (22,450 Dekatherms) per day, of which 7.6 billion Btu (7600 Dekatherms) per day is firm sales service and 14.86 billion Btu (14,850 Dekatherms) per day is interruptible Direct Authorized Overrun Service. Interruptible service is curtailed from time to time when ETNG's system reaches it maximum capacity during periods of cold weather. Curtailment notification is generally provided 24 hours in advance, but notification is sometimes four hours or less depending on the circumstances.

Starting in mid to late 1993, ETNG will no longer be the sole supplier. The Federal Energy Regulatory Commission has ordered all interstate pipelines to "unbundle" their services, thereby breaking the pipelines' monopolies and affording consumers the ability to contract separately for supplies and transportation of supplies in order to reduce gas costs. Most of the services previously provided by ETNG will become the responsibility of DOE.

Delivery of natural gas to the ORR. Natural gas is transported to the ORR through ETNG's 22-in. North, or 3100, line, operating from approximately 450 to 600 psig. This line crosses the ORR in a general west-to-east direction (Fig. 2.8). There are three delivery points from ETNG to the ORR. At each delivery point there is a station with pressure reducing and electronic flow metering equipment. ETNG owns, operates, and maintains the mainline as well as the equipment within the delivery point stations.

ETNG's 3100 line comes from the Harriman area and enters the ORR north of the K-25 Site. From there the line runs east-southeast by the northeast side of the K-25 Site, crossing Blair Road just north of Perimeter Road. This line continues along the east side of Blair Road and then across State Route 58. The "A" Station serves the K-25 Site and is located about 0.23 km (0.14 miles) south of State Route 58 and about 0.61 km (0.38 mile) east of Blair Road on State Route 58. From here, ETNG's system goes in two directions: the 3100 line continues across the ORR and the "tie line" between ETNG's 3100 and 3200 (north and south) lines runs south toward Lenoir City.

From "A" Station, ETNG's 3100 line continues 6.4 km (4.0 miles) east across Pine Ridge, Bear Creek Road at State Route 95, and Chestnut Ridge to Bethel Valley Road. "B" Station serves ORNL and is located 0.08 km (0.05 mile) north-northwest of the intersection of Bethel Valley Road and Melton Valley Road, which is about 0.23 km (0.14 mile) northeast of the old Bethel Church on Bethel Valley Road.

From "B" Station, ETNG's 3100 line runs 0.38 km (0.24 mile) southeast along the north side of Bethel Valley Road, crosses the road and continues another 8.5 km (5.3 miles) southeast along the south side of the road. "C" Station serves Y-12 and is located at the intersection of Bethel Valley Road and Kerr Hollow Quarry Road, about 0.65 km (0.40 mile) southwest of Scarboro Road.

From "C" Station, ETNG's 3100 line runs 1.4 km (0.88 mile) southeast across Haw Ridge, across the Clinch River at Mile 41.4, out of the ORR, and on toward Knoxville.

Site distribution system. Each site is responsible for its own distribution system, which begins at the outlet of each delivery point station. This responsibility is held by the following departments: Site Services Division, Power Operations Department at K-25; Plant and Equipment Division, Utilities Department at ORNL; and Facilities Management Organization Division, Utilities Operations Department at the Y-12 Plant. The capacity of the natural gas system is presented in Table 2.14.

Table 2.14

Capacity of natural gas system

	Distribution (Btu)		Percent of total		Percent of time in full use	
Station	Average day	Peak day	Average day	Peak day	Average day	Peak day
"A"	1,565,000,000	3,736,000,000	18	19	0	5
"B"	996,000,000	3,531,000,000	12	18	0	0
"C"	5,915,000,000	12,177,000,000	63	63	0	0
Total	8,476,000,000	19,444,000,000	100	100	0	0

Source: Dunlap 1993

At "A" Station, gas is measured and then the pressure is reduced to 78 psig for distribution to the K-25 Site. A 22-in. main extends about 0.61 km (0.38 mile) southwest parallel to the south side of State Route 58, at which point a 3-in. side valve provides service to the Transportation Maintenance Facility (Y-9714). The 22-in. main continues southwest another 0.52 km (0.32 mile) to a valve vault. The portion of the 22-in. main continuing southwest from the valve vault to the old powerhouse (K-701) was cut and abandoned in July 1983. From the valve vault, a 6-in. branch line runs 1.18 km 0.74 km) northwest, back across State Route 58 to the northeast corner of the steam plant (K-1501). From this point the system branches further for service to individual facilities. Each facility has its own metering and pressure regulating equipment. Most of the on-site distribution system is above ground. Approximately 80% of the natural gas is used for steam generation (for space heating and a small amount for processing), 15% for the TSCA Incinerator, and 5% for the Transportation Maintenance Facility.

The unclassified intersite IBM Network uses the Broadband Communications Network and leased 56-Kbps lines to link IBM computers at the three plant sites. This network supports intersite file transfer, interactive terminal sessions, and network job entry for interactive graphics systems, IBM systems support, and program development.

The External Communications Ethernet Segment is an Ethernet segment that provides centralized interconnection of existing, external connections to the unclassified Oak Ridge networks. Over 90 % of the spectrum-dependent assets are used in land mobile radio service at the three Oak Ridge facilities. The services include HF, VHF, and UHF band frequencies. In addition to land mobile service, there are additional networks in these same bands for one-way radio paging, remote control of overhead cranes, and various telemetry uses. The Oak Ridge sites became the first DOE complex to have an approved assignment of radio frequencies for a trunking system. The five-channel Oak Ridge Complex Trunked Radio System is located at Y-12.

The ORR's existing communications networks and systems can be expanded and augmented to accommodate requirements as they are developed in the facilities planning process. For more detailed descriptions of these telecommunication systems see *Long-Range Site Plan: Informational Technology Resources, Part 4, Telecommunications*, Martin Marietta Energy Systems, Inc., January 1991, and the TSIs for the three plant sites.

2.5.3 Transportation

The ORR has a variety of transportation resources that provide personnel access and material delivery to many locations on and off the reservation (Fig. 2.9). The following sections discuss the transportation systems that directly serve the reservation. Airports and waterways near the ORR are discussed in Sect. 1.6

Effective management of these transportation systems requires that land (rights-of-way) be dedicated for access, location, maintenance, and safety. As a land use, the primary, secondary, and access roads occupy more than 283 ha (700 acres), or approximately 2% of the land, and railroads occupy considerably less than 1% of the land.

Roads

Three state routes provide access to the ORR for employees and transient traffic. State Route 95 forms an interchange with Interstate 40 and enters the reservation from the south. State Route 58 enters the reservation from the west, passing just south of the K-25 Site. This route ends as it intersects with State Route 95, about 5.6 km (3.5 miles) from the western

ORR boundary. At this intersection, State Route 95, also called the Oak Ridge Turnpike, turns east, paralleling the northern boundary of the ORR, and continues through the city of Oak Ridge.

The major link between west Knoxville and Oak Ridge is the Pellissippi Parkway (State Route 162) which extends from I-75/I-40 just west of Knoxville and merges with Edgemoor Road, the main access route to and from southern Anderson County. State Route 62, a two-lane highway which leads into downtown Knoxville, merges with State Route 162 about 6.4 km (4 miles) east of Oak Ridge and is a principal corridor for traffic from north Knox County to the ORR.

The state routes mentioned above are probably the most important arterials in the ORR area; however, with the exception of State Route 95 serving the K-25 Site, these roads do not provide direct access to the plants and facilities on the reservation. Several other routes transfer heavy volumes of traffic from the state routes to the main plant areas. These routes handle a significant volume of traffic as a result of the high degree of interaction between the programs at the three plants.

Bear Creek Road and Bethel Valley Road are the two major components of the ORR road network. Bear Creek Road lies just north of the Y-12 Plant and extends in an east-west direction, connecting Scarboro Road on the east end of the plant with State Routes 95 and 58 to the west. For security and safety reasons, Bear Creek Road has restricted access around the Y-12 Plant and is not a public thoroughfare. Bethel Valley Road provides public access through a large portion of the ORR. This road extends from the east end of the ORR, at State Route 62, to the west end at State Route 95. Bethel Valley Road provides direct access to ORNL, passing just north of the plant. Other important access roads are Blair Road, which provides access to K-25 from the north, and Scarboro Road, which begins at the east end of Bethel Valley Road, connects to Bear Creek Road, and leads into Illinois Avenue in Oak Ridge (see Fig. 2.9).

A few other roads lead to remote facilities on the ORR and are generally used only by personnel working at these facilities. Examples are Melton Valley Road, which provides access to the High Flux Isotope Reactor and other facilities south of ORNL, and Mount Vernon Road, which extends from Bethel Valley Road north to Y-12. Most other roads on the ORR are gravel or dirt and are used for official DOE activities, such as forestry management, environmental research and monitoring, and security patrol. In recent years, DOE has allowed limited hunting on the ORR, and these roads are used by hunters on open hunting days. Most of the roads have gates to prevent public access.

The Tennessee Department of Transportation (TDOT) maintains traffic count stations at numerous locations throughout the city of Oak Ridge, Anderson and Roane counties, and the ORR for the purpose of determining average daily traffic (ADT) counts. Data are collected from these stations each spring and summarized on annual ADT maps produced by TDOT. Figure 2.10 identifies the ADT for various strategic locations (i.e., major traffic corridors) on the ORR and in the city of Oak Ridge on the basis of TDOT's 1992 counts.

Level-of-service (LOS) calculations were made from the ADT counts to gauge the operational efficiency of the reservation roadways. These are shown in Fig. 2.10 along with

2.6 PHYSICAL CHARACTERISTICS

The natural resources on the ORR affect practically every programmatic activity. Site planners must therefore work closely with the environmental programs to ensure that all planning is done in a way that will maintain a healthy ecosystem and protect important natural resources. This section is intended to acquaint the reader with the environmental factors that must be considered. The most important issue facing the ORR relative to natural physical characteristics is the legal protection afforded wetlands, floodplains, and endangered species. Such protection can preclude desired site development if proper, environmentally sound design is not pursued. Another issue is the limited land suitable for waste management activities, which should generally only be conducted on Knox soils, soils that are found in only three areas on the ORR.

2.6.1 Topography

The ORR lies in a region characterized by elongated ridges and valleys that tend in a northeast-to-southwest direction. During the early years of the Manhattan Project, the area's ridges and valleys provided safety, isolation, and separation. Each of the three major plant facilities is located in a separate but adjacent valley. Southernmost is ORNL in Bethel Valley between Haw Ridge and Chestnut Ridge (with ancillary facilities in Melton Valley to the south). To the north is the Y-12 Plant in Bear Creek Valley between Chestnut Ridge and Pine Ridge. Northernmost is the K-25 Site, which is located in East Fork Valley between Pine Ridge and Black Oak Ridge. This is the same valley in which the urban portion of the city of Oak Ridge is located. Figure 2.11 displays the topography of the ORR.

The rolling topography of the ORR consists of subtle to exaggerated slopes with minimal flat land. However, 62% of the ORR, 8745 ha (21,606 acres), lies in a mild slope category (slope less than 14%). The topography of these lands is not a development constraint. Approximately 38% of the ORR, 5285 ha (13,061 acres), has a slope greater than 14% and is thus considered to present moderate to severe constraints for development. Special care should be given to the consideration of siting facilities in these areas. Figure 2.12 illustrates the slope categorization for the ORR.

The lowest elevations on the ORR are near the Clinch River and are about 230 m (750 ft) above mean sea level (MSL). The highest elevations on the ORR are along Pine Ridge and are about 385 m (1260 ft) above MSL.

The presence of soils suitable for intensive land use is minimal. Many soils on the ORR are considered to be fragile and are easily damaged or degraded. Fragile soils are characterized as highly erosive, shallow to hard rock, and having undesirable subsoil or substratum chemical or physical properties that cannot be altered economically. Fragile lands on the ORR, shown in Fig. 2.17, are lands with fragile soil series, having slopes of 25% or greater, and with severely eroded soil phases. In general, these lands should be maintained as the scenic and natural parts of the ORR and be preserved for low intensity land use. Some lands labeled as fragile, however, can be considered for more intensive land use because the label "fragile" serves as a general warning that problems exist with the soils at a selected site, requiring significant study prior to development (Lietzke et al. 1986).

2.6.4 Groundwater Hydrology

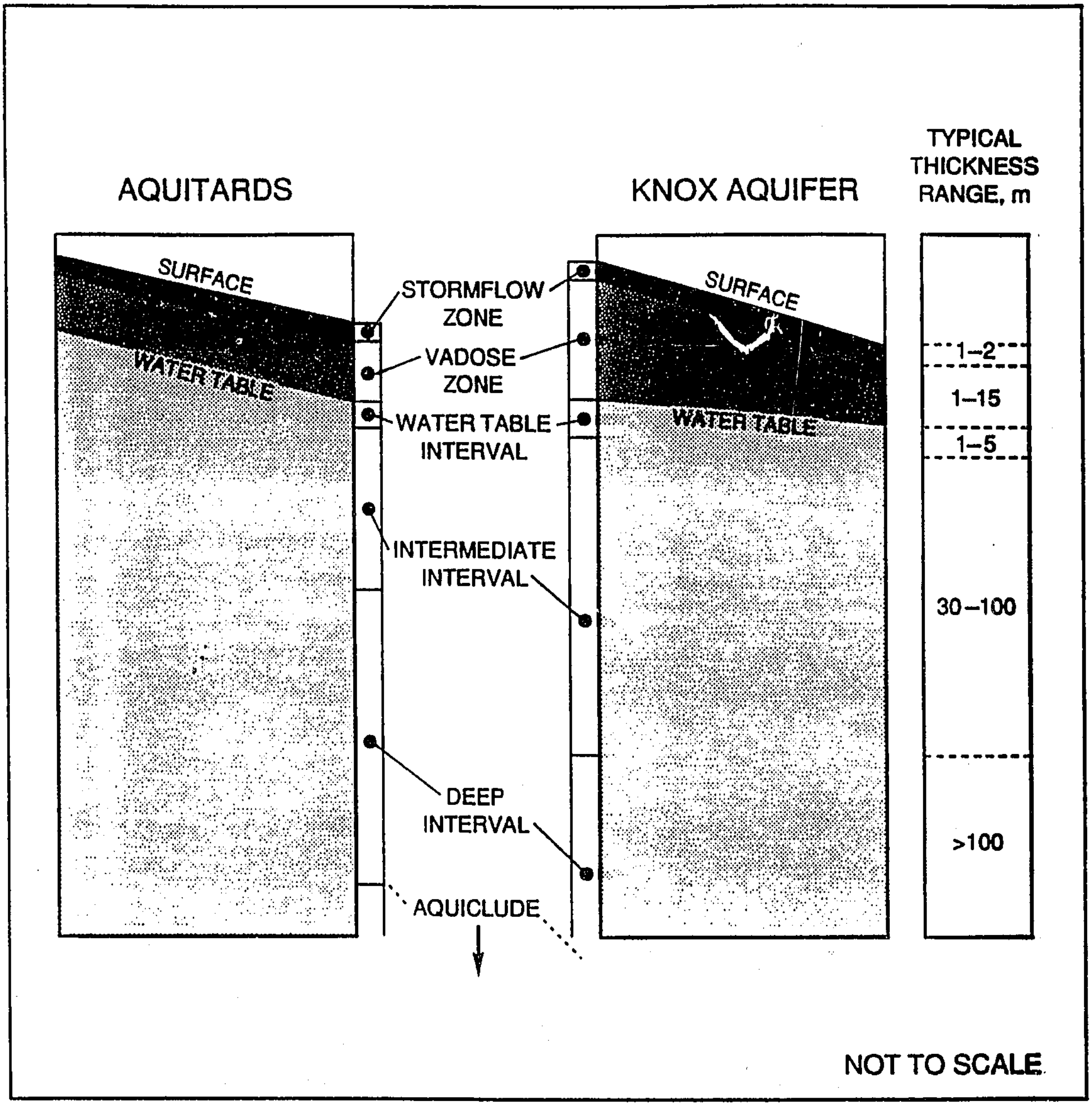
Groundwater presence and flow on the ORR is heavily influenced by the underlying geologic structure. Geologic rock units through and upon which groundwater passes affect its flow and quality. Geologic units on the ORR are assigned to two broad hydrologic groups: (1) the Knox aquifer (formed by the Knox Group and Maynardville limestone and part of the Cambrian-Ordovician Carbonate aquifer in East Tennessee) in which water presence and flow is dominated by solution conduits and which stores and transmits relatively large volumes of water, and (2) the ORR aquitards (formed by Rome, Conasauga, and Chickamauga rock units) in which flow is controlled by fractures, and which may store fairly large volumes, but transmit only limited amounts of water (Solomon et al. 1992). See Fig. 2.18 for the surface distribution of aquitards and the Knox aquifer on the ORR.

Both the Knox aquifer and the ORR aquitards are divided into the following vertical zones:

- *the stormflow zone*—a thin region near the soil surface in which transient precipitation-generated flow accounts for an estimated 90% or more of the water moving through the subsurface and which is a major pathway for transporting contaminants from near surface sources to streams;
- *the vadose zone*—an unsaturated zone mostly in soil and saprolite above the water table that may be saturated locally on a transient basis;
- *the groundwater zone*—a continuously saturated region in which most of the remaining 10% of subsurface flow occurs and which is subdivided into the water table interval, the intermediate interval, and the deep interval; and
- *the aquiclude*—a zone in which water movement is negligible (Solomon et al. 1992).

Figure 2.19 shows the vertical division of the Knox aquifer and aquitards on the ORR and their typical thicknesses.

ORNL-DWG 93M-7131



SOURCE: Adapted from Kornegay et al. 1992

Fig. 2.19

Schematic vertical relationships of flow zones of the ORR and their estimated thicknesses.

Groundwater flow is predominantly a near-surface phenomenon, influenced by topography, surface cover, and geologic structure and lithology. As such, the Knox aquifer is the primary source of sustained natural flow in perennial streams such as White Oak Creek, Walker Branch, Scarboro Creek, East Fork Poplar Creek, and Bear Creek. Also, all large springs on the ORR discharge from this aquifer. Significant water movement may also occur at great depth [>300 m (1000 ft)] along thrust faults and other large fissures in parent rock material. In some places the Knox aquifer can supply large quantities of water to wells. Flow volumes in the aquifer are significantly larger than in the aquitards, and flow paths are deeper. Additionally, the potential flow path length in the Knox aquifer is substantially greater than in the aquitards. The regional groundwater discharge area is thought to be the Clinch River, and little flow beneath it is likely. Within the ORR, streams and tributaries are local discharge areas, and groundwater divides are usually assumed to be approximately equivalent to surface water divides, except in karst areas. The one strongly suspected instance of groundwater flow across the ORR boundary occurs along Chestnut Ridge, where water from the Knox aquifer travels greater than 2.5 km (1.5 miles) and discharges to Scarboro Creek (Solomon et al. 1992, Kornegay et al. 1992).

The depth to water table is generally greatest from October to December and least from January to March. The range of seasonal fluctuations in depth to the water table and in rates of groundwater flow vary significantly across the ORR. In areas of the Knox aquifer, seasonal fluctuations in water levels average 5.3 m (17 ft), and the mean discharge from the active groundwater zone is typically 85 gal/min/mile^2. In the aquitards of Bear Creek Valley, Melton Valley, East Fork Valley, and Bethel Valley, seasonal fluctuations in water levels average 1.5 m (4.5 ft), and typical mean discharge is 26 gal/min/mile^2 (Kornegay et al. 1992, Solomon et al. 1992). Usually, flow divides, which occur beneath hills and ridges, are the areas of greatest seasonal fluctuation in water levels. The depth to the aquiclude is approximately 180–240 m (540–720 ft) in Melton and Bethel valleys, and is believed to be greater than 300 m (900 ft) in portions of Bear Creek Valley. The depth to the aquiclude in areas of the Knox aquifer is not known (Solomon et al. 1992).

In general, the groundwater quality on the ORR is good, and, with few exceptions, ORR groundwater discharges presently meet drinking water standards (Solomon et al. 1992). However, groundwater must be viewed as both a potential pathway for exposure to hazardous wastes and as a mechanism for contaminant transport. Typically, contamination is promoted by developing or using land underlain by shallow groundwater and in karst areas by the presence of numerous direct conduits to groundwater.

Contamination is often associated with leaks in waste disposal facilities and buried pipelines or accidental spills. Once within groundwater, though, contaminant migration is buffered by the transport process and related natural chemical and physical processes in the subsurface, including diffusion and adsorption. Generally, an instantaneous release of contaminants from a primary source, such as the failure of a container, will not result in an immediate loading to streams (Solomon et al. 1992). For example, contaminants such as tritium moving from a waste area can be delayed for several to many decades in the aquitards, even along flow paths as short as a few hundred feet (Kornegay et al. 1992).

However, the processes that naturally retard contaminant migration and that store contaminants in the subsurface are likely to be less effective in the Knox aquifer than in the aquitards. For this reason, landforms on the ORR aquitards are more suitable for waste storage than those on the Knox aquifer. Aquitards have shallow soils because of this impermeability. Additionally, while the transport processes through a porous subsurface serve to buffer contaminant migration, it also represents a secondary contaminant source that may persist for decades (Solomon et al. 1992).

The ORR has over 1400 groundwater monitoring wells. Two types of monitoring are required at these wells: (1) detection monitoring, to determine whether hazardous waste or hazardous waste constituents have entered the groundwater supply, and (2) assessment monitoring, to define the rate, extent, and concentration of hazardous waste or hazardous waste constituents that have entered the groundwater (Huff and Faulkner 1991). The use of wells for monitoring contaminant migration from waste areas is considered unreliable because most transport takes place near the surface; it is more valid to monitor surface-water quality and contaminant load (Solomon et al. 1992). Monitoring programs have been designed to comply fully with regulatory requirements. Further discussion of groundwater monitoring and regulatory compliance for groundwater quality can be found in Sect. 2.9.3, Environmental Monitoring.

Construction of new facilities modifies groundwater hydrology. Soil disturbance generally increases permeability, and clear-cutting of vegetation reduces or eliminates evapotranspiration, causing groundwater levels to rise. Prior to changes in land-use designation and construction of new facilities, the impact of the proposed change or use should be studied with respect to its influence on groundwater flow, level, and quality.

2.6.5 Surface Water Hydrology

The hydrologic system within the ORR is of major importance to the functioning of natural ecosystem processes as well as to the mobility and fate of contaminants. The hydrologic regime on the ORR, both surface water and groundwater, is controlled regionally by the Clinch River where water levels are regulated by TVA. The Clinch River is the primary source of raw and potable water for the ORR and the city of Oak Ridge; therefore, water quality, not quantity is the major concern of hydrologic management on the ORR, particularly as it affects waste management.

Both groundwater and surface water drain into the Clinch River through a network of small tributaries and streams on the ORR (see Fig. 2.20). Table 2.18 lists the location and drainage area of Clinch River tributaries. These tributaries form several subbasins in which the three plant sites are located (see Fig. 2.21). Drainage from the Y-12 Plant enters both Bear Creek and East Fork Poplar Creek; the ORNL area drains into White Oak Creek and several tributaries; and the K-25 Site area drains predominantly into Poplar Creek and Mitchell Branch (Kornegay et al. 1992).

Table 2.18

Location and drainage areas of Clinch River tributaries

Stream	Mouth location	Drainage area km^2	Drainage area Mile^2
Powell River	CRK[a] 142.9	2430[b]	938.0
Big Creek	CRK 133.5	174[b]	67.0
Coal Creek	CRK 120.7	95[b]	37.0
Hinds Creek	CRK 105.9	165[b]	64.0
Bull Run Creek	CRK 75.1	270[b]	104.0
Beaver Creek	CRK 63.7	234[b]	90.0
Conner Creek	CRK 57.1	16.6[b]	6.4
Walker Branch	CRK 53.1	3.89[b]	1.5
Hickory Branch	CRK 45.7	17.9[b]	6.9
Melton Branch	WCK[c] 2.49	3.83[b]	1.5
White Oak Creek	CRK 33.5	15.5–16.5[b,d,e]	6.0–6.4
Raccoon Creek	CRK 31.24	1.2[d,f]	0.4
Ish Creek	CRK 30.6	0.9[e,g]	0.3
Caney Creek	CRK 27.2	21.4[e]	8.3
Poplar Springs Creek	CRK 25.9	7.8[d]	3.0
Grassy Creek	CRK 23.2	5.0[d]	1.9
Bear Creek	EFK[h] 2.36	19.2[d]	7.4
East Fork Poplar Creek	PCK[i] 8.8	77[d]	30.0
Poplar Creek	CRK 19.3	352[d,e,f]	136.0
Emory River	CRK 7.1	2240[b]	865.0

[a]CRK = Clinch River kilometer
[b]Source: Fitzpatrick 1982
[c]WCK = White Oak Creek kilometer
[d]Source: Loar 1981
[e]Source: Edgar 1978
[f]Source: DOE 1975
[g]Source: McMaster 1967
[h]EFK = East Fork Poplar Creek
[i]PCK = Poplar Creek kilometer

A statewide stream classification system identifies various uses of ORR streams. Most streams on the ORR are classified for fish and aquatic life, irrigation, and livestock watering. East Fork Poplar Creek is the only stream (in addition to the Clinch River) on the ORR classified as an industrial water supply. Such classifications are based on water quality, designated water uses, and resident aquatic biota. For each designated water-use classification, specific water quality criteria are applied (Kornegay et al. 1992). These criteria form the basis for each facility's NPDES permit as mandated by the Clean Water Act. There are no wild and scenic rivers on the ORR, as classified by the Tennessee Wild and Scenic Rivers Act. For more detailed information on the use classification of streams and tributaries on the ORR, refer to Kornegay et al. (1992).

Stream flow in tributaries across the ORR varies greatly depending on seasonal precipitation and subsurface geology. Precipitation is the driving mechanism of the hydrologic system. The mean annual rainfall is about 1351 mm (53.2 in.). However, precipitation is not evenly distributed through the year. Five-year cycles of wet seasons and droughts are evident, and annual precipitation varies by as much as 30% (Birdwell 1993). Thus, runoff and streamflow will vary accordingly. The winter months are characterized by passing storm fronts and are the period of highest rainfall. Another peak occurs in July, when short, heavy rains associated with thunderstorms are common (Rothschild et al. 1984). These periods are associated with peak surface runoff and stream flow. Precipitation not lost through evapotranspiration or rapid runoff to streams percolates through the soil and eventually recharges the groundwater system. In terms of geologic influence, streambeds that are underlain by carbonate rocks, such as dolomite and limestone, generally have higher flow rates than streams underlain by sandstone and shale. They also tend to have higher base flows and less variation in the range of flow (Rothschild et al. 1984).

The inherent quality of surface water on the ORR is influenced by the geochemistry and soil-water interactions of the subbasins. Surface waters originating in ORR subbasins and affected by ORR facilities are of a carbonate-bicarbonate type with little or no influence from natural sulfates, nitrates, or chloride. This property is characteristic of base flow derived from limestone and dolomite formations (Kornegay et al. 1992). Surface water is a potential pathway for hazardous wastes and a mechanism for contaminant transport. Water quality is affected by wastewater discharges and by groundwater transport of contaminants from land disposal of waste. All effluent discharged from ORR facilities to receiving streams must meet various chemical limits that are specified in the NPDES permits for each site. These limits protect the classified uses of surface waters.

Water quality of surface waters on the ORR is determined and monitored by a complex surface water monitoring system. Surface water monitoring is conducted through the sampling and analysis of four functionally distinct types of water: (1) reference surface waters located upstream of ORR facilities; (2) ORR surface waters that receive effluents directly from discharge points; (3) off-reservation surface waters that receive subbasin drainage; and (4) effluents, such as liquid discharges from facility processes and surface runoff over developed areas (Kornegay et al. 1992). Detailed analyses of the water quality of ORR streams can be found in Kornegay et al. (1992). Further discussion of surface water monitoring and regulatory compliance for surface water quality can be found in Sect. 2.9.3, Environmental Monitoring.

Stream use classification and water quality are carefully regulated by federal and state governments. New construction can result in the alteration of stream courses, flow rates, sediment loading, and ability to sustain aquatic life. Prior to changes in land-use designation and construction of new facilities, the impact of the proposed change or use should be studied with respect to its influence on stream flow and water quality.

Floodplains

Executive Order 11988 mandates that all federal agencies must actively protect floodplain areas. Any activity undertaken by a federal agency must thus ensure avoidance of any long- or short-term adverse impacts associated with the occupancy and modification of floodplains and of any direct or indirect support of floodplain development wherever there is a practicable alternative. DOE shares this responsibility for the protection of floodplain areas located on the ORR. The floodplain shown on Fig. 2.20 should be viewed as a general guide to locating flood-prone areas relative to potential building sites, and not as an exact location of established flood levels. By identifying such areas, this figure illustrates the potential for floodwaters carrying contaminants into or away from a facility—a risk considered high in many flood-prone areas on the ORR (Rothschild et al. 1984). Floodplains should be surveyed at a site-specific scale for any proposed facility to determine accurate location of flood levels and their associated risks.

In December 1991, a flood analysis for the ORR was prepared by the Water Resources Division of TVA. This analysis provides a data base of flood levels for the 25-, 100-, 500-, 2000-, 10,000-, and 100,000-year flood event as well as the maximum probable flood (MPF) and probable maximum flood (PMF) levels for various mile marks on the Clinch River, East Fork Poplar Creek, Poplar Creek, Bear Creek, White Oak Creek, and Melton Branch (TVA 1991). For detailed information concerning the flood level of specific points on these waterways, refer to the 1991 TVA study.

When planning for new facilities, a design basis flood (DBF) must be established to guide design and development. The probable maximum flood serves as a preferred DBF for moderate- to high-hazard facilities (Brock and Lee 1990). The PMF (shown in Fig. 2.20) is defined by TVA as the most severe flood that can reasonably be predicted to occur at a site as a result of hydrometeorological conditions. It assumes an occurrence of probable maximum precipitation critically centered on the watershed in question and a sequence of related meteorologic and hydrologic factors typical of extreme storms. The PMF also assumes, where appropriate, the event of a dam failure as part of a probabilistic flood hazard for the watershed (UCRL-15910). According to UCRL-15910, the DBF level should correspond to a hazard level whose mean annual probability of exceedence ranges from 2×10^{-3} for low hazard facilities to 10^{-5} for high hazard facilities. The American Nuclear Society sets the DBF for nuclear reactors to be 10^{-6} (Brock and Lee 1990). The PMF is considered to have a probability of exceedence of approximately 10^{-6} to 10^{-8}. For more detailed information on the determination of an appropriate DBF for facilities on the ORR, refer to UCRL-15910.

2.6.6 Wetlands

As defined by the U.S. Corps of Engineers (COE), wetlands are:

> . . . areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (COE 1987).

Although few extensive wetlands occur on the ORR, there are many small forested, scrub-shrub, and emergent wetlands. These wetlands consist primarily of riparian, forested wetlands adjacent to streams and their tributaries. Additionally, emergent and scrub-shrub wetlands frequently occur in disturbed areas such as powerline rights-of-way, again primarily adjacent to streams. The following types of areas have been found to contain or are conducive to the presence of wetlands:

- *Clinch River shoreline*—along the eastern, western, and southern borders of the reservation, including TVA impoundments;
- *Clinch River embayments*—encompassing numerous recesses along the shoreline, including Roberts Branch embayment and Grassy Creek embayment;
- *stream bottomlands*—riparian areas, springs and seeps;
- *floodplains;*
- *agricultural ponds*—impoundments used as a water source.

Activities in wetlands are regulated by both federal and state governments. For this and other ecological reasons, all wetlands on the ORR require special consideration, especially when they are located on or near sites being studied for development.

Currently only a small percentage of wetlands on the ORR have been identified and mapped. Some of these are in National Environmental Research Park Natural Areas which have been established, in part, to protect endangered or threatened species. Table 2.19 lists wetlands found in protected Natural Areas on the ORR (see also Fig. 2.26 in Sect. 2.6.7).

Table 2.19

Wetlands in protected areas in the Oak Ridge National Environmental Research Park

Site	Location	Type of protection[a]
Rein orchid swamp	Marsh	NA-4[b]
Raccoon Creek goldenseal area	Embayment	NA-6
Pine Ridge lily area	Stream	NA-13
East Fork floodplain	Floodplain	RA-3
Bear Creek wetlands	Seeps	RA-4
McNew Hollow marsh	Marsh	RA-5[b]
Poplar Creek rookery	Floodplain	RA-23

[a] NA = Research Park Natural Area; RA = Research Park Reference Area

[b] State Natural Area

These Natural Areas are not the only locations containing wetlands on the ORR; they merely represent the location of wetlands in protected areas. A study was conducted in 1991 to determine approximate locations of wetlands throughout the ORR (Cunningham and Pounds 1991). This study relied primarily on the National Wetlands Inventory, and, due to the small scale of the map and limited field verification, did not identify all of the wetlands on the ORR. Wetland delineation must be performed on an individual, site-specific basis in order to accurately determine the presence and boundaries of wetlands. Since the publication of the study, several wetland surveys and delineations have been performed in selected areas on the ORR, including the White Oak Creek drainage area, portions of the Bear Creek Watershed, and along tributaries of Melton Branch (Fig. 2.22) (Rosensteel 1993). However, most of the ORR remains unsurveyed. For more detailed information regarding the location of wetlands on the ORR, refer to Cunningham and Pounds (1991) and the Resource Analysis Group of the Environmental Sciences Division (see Appendix A, Contacts List).

The major source of federal involvement in controlling the use of wetlands is the COE regulatory program established by Section 404 of the Clean Water Act (33 U.S.C. 1344), which regulates discharges of dredged or fill materials into wetlands. Certain activities in some wetland areas are covered by nationwide permits relating to activities occurring in waters of the U.S. that include wetlands, thus eliminating the need for individual permit review (33 CFR 330). For specific regulations governing activities falling under general permits, see *Environmental Program Reference Book: Clean Water Act (Section 404) and Rivers and Harbors Act (Sections 9 and 10)*, ORNL/M-1573. One such permit, Nationwide Permit 26, regulates activities in wetlands in headwater areas and isolated wetlands. Under this permit the following conditions apply:

- *Wetlands of less than 1 acre*—Action may proceed, but COE must be notified.
- *Wetlands of 1 to 10 acres*—COE must be notified and action may not proceed until approval is given, provided the action is covered by the existing nationwide permit. If the action is not covered, a wetlands permit application must be submitted.
- *Wetlands of more than 10 acres*—An application for an individual permit must be submitted.

These guidelines reflect COE regulations only. They do not account for state regulations that apply to the alteration of wetlands and which also must be complied with.

The primary state method of controlling activities in wetlands is through the Tennessee Aquatic Resource Alteration Permit (ARAP), enforced under the Tennessee Water Quality Control Act. ARAPs are required for any activity involving the alteration of a stream channel or wetland. There are no size constraints—all wetlands are considered waters of the state and are regulated. Regulated activities include levee construction; dredging, widening, straightening or otherwise altering any state waters; channel relocations; water diversions; water withdrawals; and flooding, excavating, or draining a wetland (Tennessee Department of Environment and Conservation 1990). The state reserves the right to deny permit applications, and mitigation is required on a basis of 2:1 or greater for wetland disturbance and on a linear foot basis for stream fills (unless the stream fill activity falls under one of the general ARAPs) (Rosensteel 1993).

All wetlands on the reservation have the potential for being adversely affected by various DOE activities. Potentially harmful activities include site development, forestry management practices, sludge application, waste disposal, and facility operations. Special consideration must be given to the possible presence of wetlands when an area is reviewed for a new land-use designation, and the proper procedures must be followed to accurately assess any wetlands present and to ensure their protection.

Public warning system

The public warning system for the X, K, and Y 2-mile immediate notification zones (the same as the EPZ) consists of outdoor warning sirens, tone alert receivers, and associated radio transmitters and receivers. The public warning system is illustrated on Fig. 2.36. The system can produce various alerting tones as well as broadcast voice messages. This system is augmented by emergency information and public service bulletins to be issued on official radio and television stations as part of the Emergency Broadcast System. The sounding of the public warning system sirens is an indication that persons who are outdoors should shelter-in-place, or find shelter where they are. The voice broadcast capability of the siren system will not normally be employed in an emergency. In addition to the public warning siren system, route alerting using emergency vehicles with public address capability can also be employed.

2.9 ENVIRONMENTAL MANAGEMENT

Environmental management is becoming one of the largest drivers for activities on the ORR. This section addresses functions or issues which relate to environmental management: waste management, environmental restoration, environmental monitoring, and NEPA.

Waste management and environmental restoration are fast becoming the predominant reservation-wide functions. Driven primarily by federal regulations, their activities require and restrict large amounts of land on the ORR. The need to meet the facility and land demands of these two programs directly conflicts with the desire to preserve and protect the natural character of the land—though, ironically, their ultimate intent is similar.

NEPA review of sites on the ORR increasingly affects and at times prolongs the planning stage for projects. Its intent to protect natural and historic areas can present difficulties in project site selection and design; however, NEPA also presents the opportunity to pursue new development guidelines to create methods for meeting development needs in a way compatible with the surrounding environment.

2.9.1 Waste Management

The Energy Systems Waste Management Organization (ESWMO) is a centralized solid waste management program that manages all solid wastes generated on the ORR. This program is involved with the treatment, storage, transportation, and disposal of the following types of solid wastes: nonhazardous, conventional radioactive, infectious, and hazardous. Solid wastes are defined as solids, liquids, or gases that are discarded, abandoned, or, in some cases, reused through recycling or burning for energy recovery. All waste management activities are conducted in compliance with state and federal regulations.

The overall guiding principals for waste management on the ORR are (1) reduce the quantity of waste generated; (2) minimize the amount of waste stored on-site; (3) characterize and certify the wastes prior to storage, processing, treatment, or disposal; (4) use on-site storage where shown to be safe and cost effective until a final disposal option is selected; (5) determine the effectiveness of promising technologies in the solution of local problems; (6) maximize the involvement of private sector contractors in conducting technology demonstrations and implementing successful technologies; and (7) maximize the use of off-site disposal (Kornegay et al. 1992).

Waste types

The DOE facilities on the ORR generate approximately 11 types of waste. These are defined as follows.

- *Sanitary/industrial waste.* Industrial trash consisting of paper, wood, metal, glass, plastic, etc., coupled with large volumes of construction/demolition debris and small volumes of sanitary/food wastes from cafeteria operations. Also included is fly ash from steam plant operations and other special wastes. These are regulated by the Tennessee Solid Waste Management Act (TSWMA).
- *RCRA hazardous wastes.* Solid wastes (including gases and liquids) that are defined as hazardous by RCRA regulations as a consequence of being a listed waste or having a hazardous characteristic.
- *Mixed wastes.* RCRA hazardous wastes that are also contaminated with radioactive material.
- *PCB wastes.* PCB oils or materials that have been contaminated with PCBs. These are regulated by TSCA, and they may or may not be radioactively contaminated. Radioactively contaminated waste cannot be disposed of through commercial facilities. Any TSCA waste that is radioactively contaminated is placed in storage pending future disposal at the K-1435 incinerator.
- *Low-level radioactive wastes.* Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or 11e(2) byproduct material as defined by DOE 5820.2A. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic is less than nCi/g.

Low-level but high activity

- *Asbestos/beryllium oxide wastes.* Solid wastes that have been contaminated with either asbestos or beryllium oxide, making them special wastes as defined by TSWMA. Such waste may also be contaminated with uranium or other radionuclides.
- *Scrap metal.* Waste derived primarily from demolition activities. It may be either uncontaminated or contaminated with uranium or other radionuclides.
- *Classified wastes.* Classified wastes include liquid and solid streams containing materials or information that, for security reasons, are restricted by DOE criteria. These wastes could be contaminated with radioactivity.
- *Medical wastes.* Medical and infectious wastes include contaminated bandages, sharps, and culture media. These wastes are placed in biological disposal containers and autoclaved to destroy any biologically active organisms. The waste is then placed in the Y-12 Centralized Sanitary Landfill II.
- *Nonhazardous wastes.* All other types of waste (including liquids) that are nonhazardous or nonradioactive, or both.
- *Material access area (MAA) wastes.* Wastes that are removed from MAAs, including combustible and compactible materials and noncombustible and noncompactible materials. Such waste contains low concentrations of enriched uranium and has been monitored to verify that the uranium concentrations are below levels of concern (Kornegay et al. 1992).

Waste treatment, storage, and disposal

Each plant is responsible for its own air and wastewater discharges and the associated treatment facilities. Nonradioactive hazardous wastes are also handled by each plant, either on-site or by shipment to off-site commercial treatment or disposal enterprises. Detailed descriptions of the air, wastewater, and hazardous wastes generated by each plant and the plant-specific facilities and operations for their treatment may be found in the TSI for each plant, and in *ORR Waste Treatment, Storage, and Disposal Facilities Site Maps and Facility Identification* (ES/EN/SFP-6/R1). Facilities for managing radioactive wastes, radioactive mixed wastes, and sanitary and industrial solid wastes are described here because they generally involve more than one of the plants and/or involve land or facilities outside the plant boundaries. Figure 2.37 shows waste management areas on the ORR. Management practices for each of these wastes is in a state of change as disposal sites approach capacity and regulatory changes require more stringent controls. Current and planned practice and facilities are described below.

Radioactive waste. For each of the two types of radioactive waste generated on the ORR—LLW and TRU waste—current waste management practice is considered a temporary solution while more permanent ones are developed. Solid LLW is currently either disposed of by placement in the greater containment disposal well or the tumulus facilities in Solid Waste Storage Area (SWSA) 6, or is stored at various locations for future treatment or disposal. Much of the volume of LLW on the ORR is generated at Y-12 and is being held in interim storage. Liquid LLW is being solidified or stored awaiting solidification.

The long-term strategy is to segregate LLW into the following five classes:

- *Below regulatory concern waste.* LLW suitable for disposal in a sanitary/ industrial landfill and that will not expose any member of the public to an effective dose equivalent of more than 4 mrem/year at the time of disposal.
- *Class L-I waste.* LLW suitable for disposal using sanitary/industrial landfill disposal technology and that will not expose any member of the public to an effective dose equivalent of more than 10 mrem/year at the time of disposal.
- *Class L-II waste.* LLW primarily containing fission product radionuclides with half-lives of 30 years or less suitable for disposal in engineered facilities designed to isolate the waste from the environment and public for a period of time sufficient to allow for the decay of radionuclides to such a level that any member of the public will not be exposed to an effective dose equivalent of more than 10 mrem/year.
- *Class L-III waste.* LLW consisting of radionuclides with long half-lives that will be disposed of in facilities having permanent intruder protection.
- *Class L-IV waste.* LLW not suitable for disposal on the ORR and that would require either treatment to reduce the level of contamination to a level consistent with any of the other waste classifications or shipment to an off-site LLW disposal facility.

The proposed long-term strategy for LLW management on the ORR calls for segregating LLW into the following classes:

- *Exempt wastes*. LLW that can be demonstrated to have contamination levels for any radioactive or hazardous materials sufficiently low to be disposed of as sanitary-industrial wastes in permitted landfills on the ORR.
- *Disposable wastes*. LLW or mixed waste appropriate for disposal at operating ORR disposal facilities that meet the waste acceptance criteria of the facilities.
- *Off-site wastes*. LLW that does not satisfy the classification criteria for exempt or disposable wastes. These wastes will be treated and packaged for shipment to an off-site facility. Wastes in this class are intended for off-site disposal because of insufficient disposal capacity or performance assessment limitations for disposal on the ORR.

The ESWMO is responsible for developing facilities for the disposable class, including Class L-I and L-II disposal. The off-site class of waste is unsuitable for disposal on the ORR and will eventually be transported to another, as yet unidentified DOE site for disposal. DOE is preparing an EIS on this strategy and on plans for a line-item project to construct facilities for L-I and L-II disposal; a draft is scheduled to be issued in October 1993, and the final EIS is due out in late 1994.

ORNL has a large inventory of TRU waste in storage and continues to generate these wastes from its production of TRU isotopes. This waste will eventually be disposed of in the Waste Isolation Pilot Plant (WIPP) in New Mexico. These wastes are in the form of solids stored in drums or sludges stored in tanks. The Waste Handling and Packaging Plant (WHPP) is proposed to be built in Melton Valley to prepare and package this waste for shipment to WIPP, and to prepare and package a smaller quantity of TRU waste from other DOE installations. Because tank storage space is rapidly being depleted, two solidification campaigns have been conducted and others are being planned as contingency measures.

Treatment of the current inventory of contaminated scrap metal at the K-25 Site and Y-12 Plant is expected to occur over the next 3–5 years as part of a comprehensive DOE Scrap Metal Program. Under this program, the scrap metal will be processed for beneficial reuse.

Radioactive mixed waste. Radioactive mixed waste (RMW) is regulated both as radioactive waste and as hazardous waste. Regulation of RMW involves the EPA, state governments, and DOE. In addition, the Land Disposal Restrictions of 1984 and the Federal Facilities Compliance Act of 1992 require all federal facilities to have in-place treatment plans for the management of site-related wastes that are also in compliance with state regulations. Such a treatment plan for ORR generated wastes is due in approximately 2 years. Management requirements are still uncertain for some wastes, and few treatment facilities (and only one off-site disposal facility) are licensed for RMW. At present, most RMW streams on the ORR are being stored awaiting development of treatment or disposal facilities.

The major RMW treatment facility on the ORR is the TSCA Incinerator. Located at the K-25 Site, it is designed to incinerate uranium-contaminated PCB wastes and other RMW. This incinerator could potentially also treat RMW from the Portsmouth Uranium Enrichment Plant, the Paducah Gaseous Diffusion Plant, Reactive Metals, Inc., and the Fernald Feed Materials Production Center should the waste shipment moratorium end.

Energy Systems' general strategy for RMW is to treat, delist, or otherwise manage it so that it can ultimately be disposed of as either hazardous or radioactive waste rather than as mixed waste. A total of 370 separate hazardous or RMW streams have been identified at the five plants in Oak Ridge, Paducah, and Portsmouth, of which about 35% are RMW, composing more than half of the volume (DePaoli, Rivera, and Eisenhower 1990). Managing this wide variety of waste types will require numerous specialized facilities, as defined in the Land Disposal Restrictions of 1984 and the Federal Facilities Compliance Act of 1992 treatment plans.

Sanitary and industrial waste. Nonhazardous, nonradioactive solid wastes, including sanitary waste and construction debris from the three plants and steam plant ash from ORNL and the K-25 Site, are buried in either the Centralized Sanitary Landfill II or the Industrial Waste Landfill IV, both located on Chestnut Ridge south of Y-12. Sanitary Landfill II is nearly full. An expansion for this landfill (Landfill VI) is being planned to dispose of Class IV wastes; however, the expansion capacity of the current landfill is limited. Plans are also being developed for new landfills (V and VII) on Chestnut Ridge. Landfill V will be a steam plant ash disposal (SPAD) landfill capable of holding Class II wastes, and Landfill VII will be a SPAD landfill capable of storing Class IV wastes.

Ash from the Y-12 steam plant is currently sluiced into McCoy Branch, a practice that violates the Tennessee Water Quality Control Act. Y-12's compliance plans include dry ash handling systems and the new industrial landfill on Chestnut Ridge.

Currently, waste treatment, storage, and disposal is required for locally generated wastes—those wastes generated as a part of ORR operations, or those accepted by DOE from local hazardous waste generators. A moratorium is currently in effect for the state of Tennessee precluding the acceptance of waste materials from out of state. As presented in a 1989 letter to then Energy Secretary James Watkins, Governor Ned McWherter said he supported the continued storage of wastes in Tennessee until disposal facilities become available. "At the same time," he said, "I will oppose the storage in Tennessee of any further waste generated in other states" (Munger 1992b). This policy has been expressed numerous times as wastes generated from out-of-state areas such as the Rocky Flats nuclear weapons plant and Weldon Springs cleanup site have been denied access to treatment or storage facilities on the ORR (Munger 1992b).

All waste management activities on the ORR are regulated by federal and state statutes as well as DOE implementing orders. For information on the statutes applicable to waste management activities, refer to Sect 1.9, Laws, Regulations, and Agreements. Management of radioactive wastes, waste by-products, and radioactively contaminated facilities is governed by DOE Order 5820.2A, which applies to all DOE elements, contractors, and subcontractors that manage radioactive waste. Guidelines are provided in this order for the characterization, storage, and disposal of high-level radioactive waste, LLW, TRU, wastes contaminated with naturally occurring radionuclides, and decommissioning wastes. Hazardous and mixed waste management is conducted under DOE Orders 5400.1 and 5400.3. The former requires that hazardous waste generated by DOE activities be managed in an environmentally sound manner, while the latter provides requirements for hazardous waste management programs implemented at DOE installations.

Facilities

As wastes continue to be generated, many waste management facilities on the ORR are at or nearing their capacity. This is evident for all classes of waste, a critical need having been identified for storing the backlog of TSCA wastes awaiting treatment. There is an immediate need for additional facilities in which to dispose of, store, or treat wastes on-site. Several facilities have been planned to address this need, including the Mixed Waste Treatment Facility, the ORR Storage Facility, the Waste Characterization Facility, the Central Neutralization Facility, several new landfills and landfill expansions, Class I and II disposal facilities, and the Waste Handling and Packaging Plant.

2.9.2 Environmental Restoration

The Energy Systems Environmental Restoration (ER) Program is the centralized organization responsible for program management and implementation of environmental restoration activities for the ORR Superfund Site encompassing each of the DOE installations on the ORR, as well as areas outside the installations, land used by ORAU/ORISE, and waterways contaminated by releases from the installations. The ORR was placed on the National Priorities List under CERCLA on December 21, 1989, thus requiring full integration of the CERCLA process into remedial activities. To date, approximately 650 sites requiring evaluation have been identified (Environmental Restoration Division 1992). Types of remedial action required at each site vary according to the source and type of contamination. Cleanup of the ORR is expected to take two to three decades and cost several billion dollars.

The fundamental goal of the ER Program is to ensure that risks to the environment and to human health and safety posed by inactive and surplus facilities and by sites contaminated by radioactive, hazardous, or mixed wastes are either eliminated or reduced to prescribed, safe levels. The ORR Federal Facility Agreement, an interagency agreement among DOE, the EPA, and the TDEC, was entered into to coordinate remediation activities undertaken on the ORR and to ensure compliance with applicable laws and regulations (Environmental Restoration Division 1992). A site management plan entitled *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program*, DOE/OR-1001/R2, was developed to supplement this agreement and to describe the overall approach for addressing environmental contamination problems on the ORR.

Operable units

The ORR generates a variety of hazardous, radioactive, and mixed wastes, some of which have been released into the environment on the ORR. The ORR has been partitioned into operable units (OUs) which are prioritized for cleanup to achieve the most effective and rapid investigation and cleanup possible. The CERCLA process is used to guide remediation activity at each OU (Fig. 2.38). For more detailed information on the CERCLA process, refer to Environmental Restoration Division (1992).

An OU is defined as a waste area grouping (WAG) or contaminated unit for which a remedial investigation/feasibility study will be performed, including any interim and/or removal actions. There are two types of OUs: source control OUs and integrator OUs. Source control OUs represent WAGs or units that are a specific source of contamination. Integrator OUs broaden this definition to include the effects of groundwater and surface water contaminant migration. An integrator OU can thus encompass a number of source control OUs serving as contaminant sources to a single hydrologic regime (Environmental Restoration Division 1992). The source control and integrator OUs on the ORR are shown on Figs. 2.39 and 2.40, respectively.

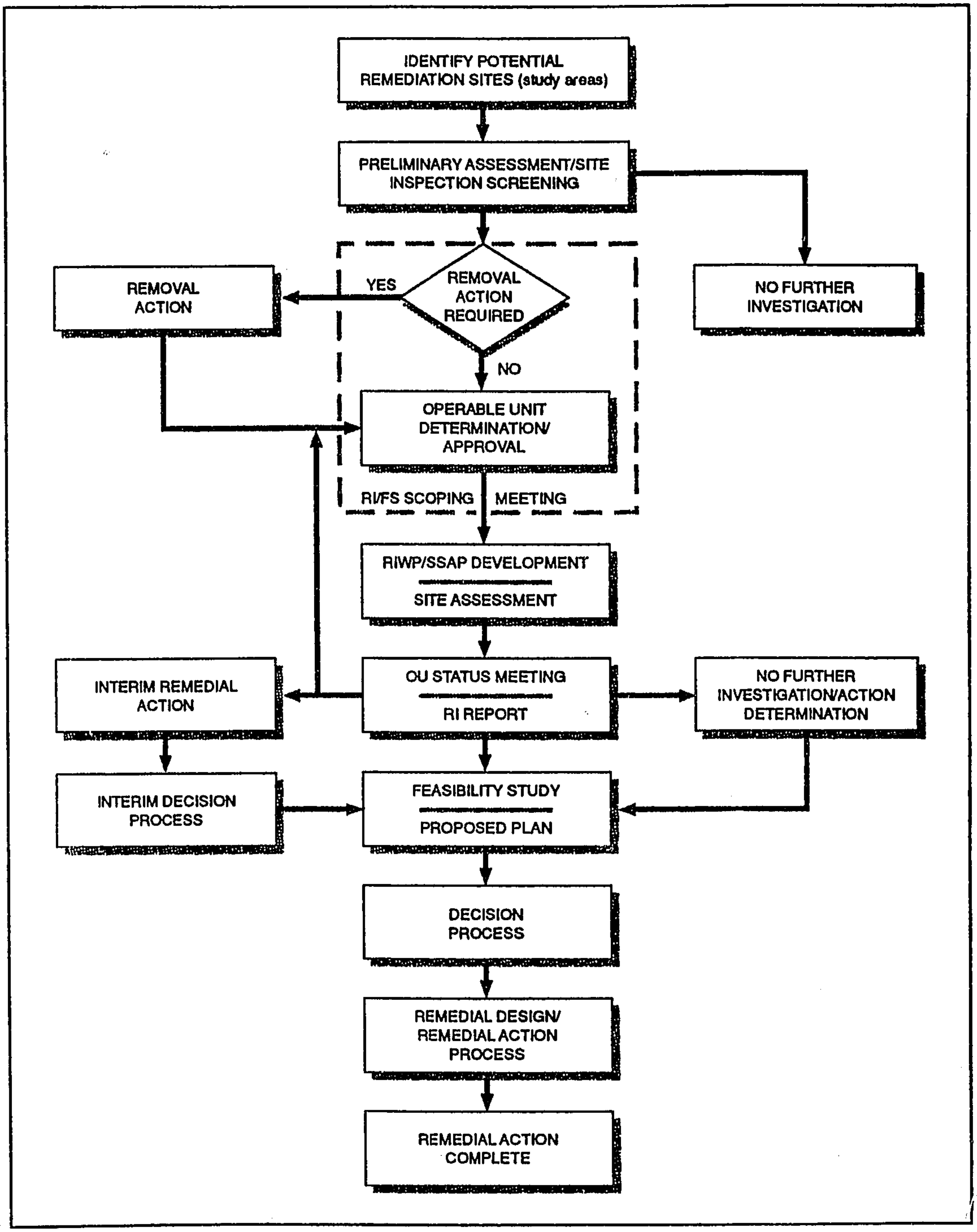
OUs on the ORR are assigned to a specific facility for management purposes. OUs at ORNL consist primarily of the WAGs which are a part of the site. The term WAG and OU relative to the waste sites at ORNL are virtually synonymous, and the term WAG is being retained until the units are reorganized into OUs. There are 12 WAGs at ORNL within the ER Program. Additionally, two integrator units are assigned to ORNL: the Bethel Valley groundwater OU and the Melton Valley groundwater OU.

There are two areas associated with ORAU: the Freels Bend Study Area OU and the South Campus Facility OU. The South Campus Facility OU is located off-site in the city of Oak Ridge.

Fifteen OUs have been identified at the K-25 Site, and three additional study areas have been designated for preliminary assessment. The study areas will require additional examination to determine whether a remedial investigation is necessary. Of the 15 OUs, only 1, the K-25 groundwater OU, is an integrator OU.

Over 200 areas of concern have been identified at the Y-12 Plant resulting from past waste management practices. Many of these areas have been grouped into OUs based on priority, common assessment, and remediation requirements. Eleven OUs constitute 31 areas within the plant boundary and its surrounding environs. Each of the Bear Creek and Upper EFPC hydrologic regimes are associated with integrated surface and groundwater OUs. The Lower EFPC and the Chestnut Ridge OUs constitute both source control and groundwater OUs. The remaining seven OUs are source control OUs within the Bear Creek and Upper EFPC hydrologic regimes. The remaining areas grouped into the Y-12 study area constitute lower priority areas requiring preliminary assessment.

ORNL-DWG 93M-7136



INDEX/KEY

RI/FS – Remedial Investigation/Feasibility Study

RIWP/SSAP – Remedial Investigation Work Plan/Site Sampling and Analysis Plan

OU – Operable Unit

SOURCE: Environmental Restoration Division 1992

Fig. 2.38
CERCLA process overview.

The Clinch River is the final OU site. It is an integrator OU which focuses on the portions of the Clinch and Tennessee rivers that may be adversely affected by contaminants released from the ORR. It surrounds a large portion of the ORR and is not represented on Fig. 2.39. For more detailed information on specific OUs at each of the facilities, see Environmental Restoration Division 1992.

OUs are classified as having high, intermediate, and low cleanup priority. High priority is based upon the high potential for exposure to humans, the environment, and any cleanup required to fully study and address other OUs. Intermediate priority is assigned to those units with moderate potential for exposure to humans and the environment and for units with potential for recontaminating other OUs. Low priority is assigned to all other units. Table 2.23 reflects the current ORR OU ER Program priorities. It is separated into columns representing DOE's budgeting of the three installations and the ORAU and Clinch River areas. The OUs within each installation/area are listed in order of highest priority.

Table 2.23

ORR operable unit prioritization table

K-25 Site	ORNL	Y-12	Other[a]
K-1070 C/D	WAG 1	Upper EFPC OU 1	Clinch River/Watts Bar
K-901	WAG 2	Bear Creek OU 4	Lower EFPC
K-770	WAG 5	Chestnut Ridge OU 1	South Campus
K-1420	WAG 4	Bear Creek OU 3	Freels Bend
K-1407	WAG 7	Bear Creek OU 1	
K-1401	WAG 6	Chestnut Ridge OU 4	
K-1004	WAG 13	Chestnut Ridge OU 2	
K-1064	WAG 11	Bear Creek OU 2	
K-1007	WAG 8	Upper EFPC OU 2	
K-1410	WAG 9	Upper EFPC OU 3	
K-25 groundwater	WAG 3	Chestnut Ridge OU 3	
K-33	Bethel Valley groundwater		
K-29	Melton Valley groundwater		
K-1413	WAG 10		
K-25			

[a] Includes Clinch River, ORAU, and Lower EFPC.
Source: Environmental Restoration Division 1992

Future land use

Prioritization of remedial activities in designated OUs involves an evaluation of human health risks associated with those units. This assessment requires consideration of risk on the basis of the potential future land use of the contaminated areas evaluated. Such land-use assumptions determine the individual human receptor used to define the reasonable maximum exposure scenario. CERCLA requires that the baseline risk assessment address the potential land use associated with the highest level of exposure risk (i.e., residential) (Environmental Restoration Division 1992). Even though institutional controls are currently in place on the ORR, risk assessment cannot exclude the possibility that certain areas on the ORR may eventually become residential. A residential future land-use scenario defines the reasonable maximum exposure to be a family setting up residence on the hazardous waste site, conceivably growing crops, and raising livestock. Such a scenario guides the "ultimate remedy" selected for contaminated areas.

In order to better identify the impact of land-use assumptions in the cleanup process, risk assessments will examine risks associated with various land-use scenarios: residential, agricultural, industrial, and recreational. These assessments will support the development of a "risk-based" future land-use plan for the ORR defining potential future land use on the basis of the associated health risk in a certain area. As with many ER Program activities, this plan is in the early stages of development. The results of this study will be addressed in future iterations of this document.

ER related programs

There are numerous other programs that are related to the central ER Program. For more information on the programs summarized here see Environmental Restoration Division (1992).

ORR Decontamination and Decommissioning (D&D) Program. D&D Program activities on the ORR consist of five individual plant-specific programs (including ORAU) that provide for the safe caretaking and disposition of retired, DOE-owned nuclear facilities. The ORR D&D Program includes 70 facilities at the K-25 Site, 27 shut-down projects at ORNL, Building 9701-4 at Y-12, and some possible animal facilities on the south campus of ORAU. The facilities currently included in the D&D Program are varied, including mercury-contaminated equipment and structures, hot cells, experimental reactors, and uranium enrichment equipment and structures. The facilities have a wide variety of contaminants, including PCBs, friable and nonfriable asbestos, chlorofluorocarbons, chromates, lubrication oils, miscellaneous RCRA materials, uranium, and other radionuclides.

ER Waste Management Program. This program provides centralized management, program planning, procedure development, and funding to ensure consistent ongoing support for activities associated with the generation of ER waste. The ER Program is responsible for the management and disposition of the waste it generates. It may, however, according to a memorandum of understanding (MOU) between the DOE Office of Waste Management and the DOE Office of Environmental Restoration dated September 15, 1992, coordinate waste management with ESWMO to make use of existing or planned waste management facilities developed as part of other DOE program responsibilities for treatment, storage, and disposal. The MOU makes this option available by stating in part that the waste management organization established at a site is responsible for the treatment, storage, and disposal of wastes generated by remedial activities conducted by the environmental restoration organization present on that site. Implementation of this agreement on the ORR occurs at the area of contamination (AOC), where wastes are treated within the AOC by the ER waste management organization as part of the defined remedial action for that area. Waste streams generated by remedial activity requiring further treatment, storage or disposal are then prepared by ER for removal from the AOC. Wastes to be removed must meet all requirements for treatment, storage or disposal as set by ESWMO. Once wastes are transported out of the AOC, they become the responsibility of ESWMO (Little 1993). For planning purposes, the ER Waste Management Program provides the ESWMO with estimates and projections for future waste generation and required treatment, storage or disposal. Thus, facility requirements for the ESWMO are representative of the needs of the ER Waste Management Program.

Reservation Groundwater Program. The Groundwater Program Office (GWPO) was established in May 1991 as a means of providing a consistent approach for all groundwater programs on the ORR, at the Paducah Gaseous Diffusion Plant, and at the Portsmouth Uranium Enrichment Plant. The GWPO interfaces with the Groundwater Protection Program Manager (GWPPM) at each of the ORR plant complexes. The GWPPM serves as the single point of contact at each facility for all activities related to groundwater. Any activity related to monitoring well installation, groundwater sampling, analyses, data interpretation, and reporting is within the purview of the GWPPM. The Oak Ridge Hydrologic Support Program (ORHSP) provides support and assistance to the GWPO and GWPPM. ORHSP is made up of three components: technical support, environmental surveillance, and the ORR Hydrologic and Geologic Studies (ORRHAGS) Program. The ORRHAGS Program is responsible for developing a fundamental understanding of the underlying principles that control groundwater flow and contaminant migration on the ORR. The key activities performed by the GWPO are (1) the establishment of a consistent set of plans, procedures, and specifications that will implement the groundwater programs at each facility; (2) oversight of establishment of a consolidated data base for groundwater data (well construction information, geologic data, hydrochemical results, hydraulic testing results, etc.) and development of consistent data verification and validation protocols; and (3) development of a consistent strategy for groundwater monitoring activities.

Well Plugging and Abandonment (P&A) Program. The objective of this program is to ensure that all wells and boreholes no longer in use are sealed to eliminate conduits that could allow (1) contamination from the ground surface to reach the water table or (2) movement of contaminants between aquifers. In addition, the P&A Program will also remove casings that could provide an obstacle to construction or installation of impermeable caps on areas to be remediated. On the ORR, there are over 2300 known wells and boreholes that must be evaluated for possible P&A. In general, P&A Program projects are coordinated with remedial investigation and unit remediation tasks.

Analytical Laboratories Program. Each of the three ORR installations have analytical laboratories which are responsible for the analytical needs of their facility programs. In order to coordinate the overall analytical workload for programs that are not facility specific (such as D&D, other ER, and WM), the Analytical Program Office (APO) was formed in the spring of 1991. This office serves the various facility laboratories by helping to level their analytical workload overflows through the placement of analytical work with the facility laboratories and at outside commercial laboratories. The APO reviews project plans, sampling and analysis plans, and task orders containing analytical support requirements, and coordinates the establishment and maintenance of standards to lead to the transparency of analytical data and the consistency of analytical procedures in programs.

Environmental Data Management Program. The primary goal of this program is to establish a system to provide consolidated, consistent, and well-documented data products to support ER activities on the ORR. This system, known as the Oak Ridge Environmental Information System, will be used to manage, process, and report consolidated environmental data gathered by various facilities, programs, and projects on the ORR and will replace a complex of independent systems and data bases currently in use. The data management program will establish standards, policies, and procedures for ER Program data activities to ensure improved documentation and reliability of the data and to allow for integrated multidisciplinary ER Program assessments.

Facilities

Planned facilities supporting ER activities in the OUs will be accommodated within the boundaries of the OUs. These facilities may include mobile treatment units or mobile office space. Most other treatment, storage, or disposal facilities will be provided by the ESWMO with its administrative facilities located at the K-25 Site. Refer to the K-25 Site TSI for information on facilities planned for ER activities at that site.

2.9.3 Environmental Monitoring

Environmental monitoring on the ORR consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples, or measurements, of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples, or direct measurements, of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs. Environmental monitoring is performed by each site for the purpose of characterizing and quantifying contaminants, assessing radiation exposures of members of the public, demonstrating compliance with applicable standards and permit requirements, and assessing the effects, if any, on the local environment (Kornegay et al. 1992).

The samples are analyzed for various radioactive, physical, and chemical parameters. In some cases, such as liquid effluent outfalls, the discharge permit may require the analysis of more than 60 different parameters (Kornegay et al. 1992). Environmental monitoring activities serve to comply with DOE and regulatory requirements and provide a historical record of ambient environmental conditions. Summaries of monitoring results are published in the annual *Environmental Report for the Oak Ridge Reservation.*

The five monitoring networks that are associated with the operation of facilities on the ORR are those

1. within the boundaries of the K-25 Site,
2. within the boundaries of the Y-12 Plant,
3. within the boundaries of ORNL,
4. outside the plant boundaries and in the vicinity of Oak Ridge, and
5. off the ORR, with stations extending from 19 to 120 km (12 to 75 miles) from the Oak Ridge area.

Local monitoring networks within the boundaries of each plant provide information on releases from each facility. Stations outside immediate facility boundaries are part of the perimeter network designed to measure releases to the general Oak Ridge area. The remote system provides background data for evaluating the impact of facility operations. Figure 2.40 shows locations of environmental monitoring and sampling stations on the ORR. The following information, unless otherwise noted, is summarized from *Environmental Monitoring Plan for the Oak Ridge Reservation* (DOE/OR-1066) prepared by DOE-ORO in 1992.

Effluent monitoring

Effluent monitoring is conducted on surface water, groundwater, and airborne emissions. Surface water monitoring is conducted to demonstrate compliance with federal, state, and DOE regulations, and is implemented through issuance of NPDES permits. NPDES permits are concerned with defining limits on the amounts and concentrations of specific chemicals that are allowably discharged into surface waters. While they do not set limits for radiological species, these types of releases are limited by DOE Orders 5400.1 and 5400.5. Information is reported to the state of Tennessee in accordance with a comity agreement between the state and DOE. NPDES permits are focusing less on the contaminant discharge amounts and more on the impact of discharges on the biota of receiving streams. The state requires that each permitted site go beyond "end of pipe" monitoring and incorporate radiological and biological monitoring programs. Information on the NPDES permits held by each of the three plants, effluent discharge locations, and the monitoring results for each can be found in DOE-ORO (1992).

Biological monitoring is a major component of the environmental compliance programs at the three sites on the ORR. Because effluents from these facilities are discharged to small streams, dilution is minimal and State of Tennessee water quality standards cannot be currently met. To address this problem, the NPDES permits that were issued for each facility under Section 402 of the Clean Water Act required the development and implementation of a Biological Monitoring and Abatement Program (BMAP) for streams receiving effluent discharges. The BMAP requirement provides a framework for establishment of interim, less restrictive effluent limits until new wastewater treatment facilities and other remedial actions are completed and water quality standards can be met. Biological monitoring in this compliance framework is used to determine if these interim limits adequately protect the classified uses of the receiving streams (e.g., growth and propagation of fish and aquatic life). The BMAPs can also be used to assess ecological impacts and identify the source of these impacts and to evaluate the effectiveness of remedial action programs by documenting the ecological recovery of these streams.

The BMAPs consist of four primary tasks: (1) ambient toxicity testing, (2) bioaccumulation monitoring, (3) measuring selected biochemical and histopathological parameters to assess fish health, and (4) benthic invertebrate and fish community sampling. These tasks use techniques ranging from laboratory bioassays and manipulative field experiments to routine biotic surveys; they combine established monitoring protocols with innovative, state-of-the-art techniques to document regulatory compliance and to ensure environmental protection and restoration.

Effluent monitoring for groundwater is conducted near potential sources of contamination, including landfills and other waste storage or disposal areas. Groundwater wells are used to determine levels of radionuclides, organics, heavy metals, and water quality parameters. Such monitoring is done not only to ensure regulatory compliance but also to evaluate the need for remedial action at a site, evaluate the effectiveness of remedial action at a site, and support the permitting process. Airborne emissions monitoring involves the sampling of airborne releases from approximately 660 permitted release sources. Principally, such monitoring is accomplished through stack monitors measuring the concentration of gases released and the exposure levels in the local environment. Analyses are conducted for radionuclides, fluorides, sulfur dioxides, suspended particulates, and some heavy metals such as chromium, lead, and nickel.

Environmental surveillance

Environmental surveillance is conducted on ambient air, groundwater, surface water, vegetation and soil, wildlife, and external gamma radiation. Such surveillance is designed primarily to ensure compliance with DOE Order 5400.5, which establishes a radiation protection standard of 100 mrem/yr for members of the public and environment. This limit is substantially tighter than those established by the implementing regulations of the Clean Air Act (10 mrem/year) and the Safe Drinking Water Act (4 mrem/year). Routine environmental surveillance of no less than once per year is conducted on the ORR to ensure compliance with the standard. Table 2.24 identifies the types of surveillance performed on the ORR and their frequency.

Table 2.24

Routine environmental surveillance on the ORR

Program	Number of locations	Sampling frequency	Sample type
Groundwater, K-25 perimeter	8 wells, 3 surface water	Annual	Grab
Groundwater, ORNL perimeter	20 wells, 4 streams	Annual	Grab
Groundwater, Y-12 perimeter	Approx. 14 wells, 3 streams	Annual	Grab
Surface water	22	Bimonthly	Grab
Sediment	16	Annual	Composite
Aquatic biota	14	Annual	Grab
Air, filters	10	Weekly	Quarterly composite
Air, silica gel	10	Biweekly	Monthly composite
External gamma	5	Weekly reading	Continuous
Milk	5	Monthly	Grab
Food crops	10	Annual	Grab
Soil	10	Annual	Grab
Hay	3	Annual	Composite
Wildlife	N/A	Annual	Grab
Groundwater, off-site culinary	20	Semiannual	Grab

Source: DOE-ORO 1992

Air is the primary pathway for humans to become exposed to radionuclides released to the atmosphere. Monitoring and control of such exposure has been elevated to a compliance program. Air sampling is done to evaluate potential doses to environmental populations. Eight sampling stations are located on or near the ORR (Fig. 2.41). Two background ambient air samplers are located at Fort Loudon and Norris dams to survey ambient concentrations of radionuclides in the atmosphere.

External gamma radiation monitoring assesses the actual or potential radiation dose to persons living near the ORR, visiting facilities on or passing through the ORR, or fishing and boating in creeks or rivers near the ORR. Several locations on the ORR have been identified as having external radiation levels above ambient background including the ORNL "cesium field". Estimated doses relating to these sites are, however, below the DOE standard. Sampling for external gamma radiation is done at five of the eight ambient air monitoring stations and at one background station (yet to be determined) on a continuous basis.

The groundwater surveillance monitoring program has two elements: (1) plant perimeter surveillance monitoring and (2) off-site water well surveillance. Plant perimeter surveillance monitors the exit pathways that contaminated groundwater would have to travel from each plant to reach the accessible environment. The program is designed to monitor any effects the plant has on local groundwater and/or surface water quality, consistent with the objectives of DOE Order 5400.1. Perimeter sampling locations, parameters, and frequencies are determined through evaluating the best technical information available on the hydrogeologic setting of the plants. Off-site water well surveillance is not specifically required but is conducted primarily to address areas of public interest or concern. Off-site water well sampling locations, parameters, and frequencies are determined primarily by availability of suitable existing wells, public interest, and legal and economic constraints; and secondarily by the technical criteria applied to plant perimeter surveillance. Plant perimeter and off-site wells analyze samples for the presence of volatile organic compounds, gross alpha and beta particles, strontium, tritium, metals, and other radionuclides.

Surface water sampling sites are located on (1) selected receiving streams immediately downstream from all possible contaminant sources, (2) public drinking water supply intakes, and (3) reference streams, either off-site or upstream of DOE facilities. Contaminant sources include both point sources and nonpoint sources. Samples are both filtered and unfiltered and are analyzed for the presence of contaminants similar to those mentioned in groundwater sampling. Fish are also sampled at these monitoring locations. A minimum of four samples per site are taken and tested, primarily for metals and PCBs.

Contaminants released from the ORR may reach soil and vegetation by deposition of airborne materials and through water irrigation and can subsequently accumulate in food crops and terrestrial animals. Thus ingestion is an important exposure pathway for humans. Monitoring of this pathway consists of measuring uptake in soil, grass, deer muscle, and cow's milk. Radionuclides are analyzed in deer killed on the ORR, Canadian geese, and in milk sampled from surrounding dairies.

Further information on the Environmental Monitoring Program on the ORR can be found in Kornegay et al. (1992) and in DOE-ORO (1992).

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